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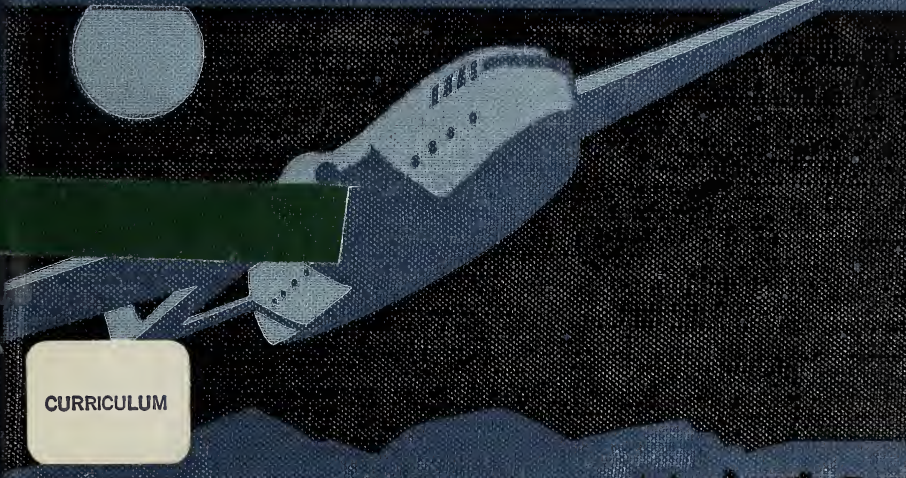

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New Ideas in Science

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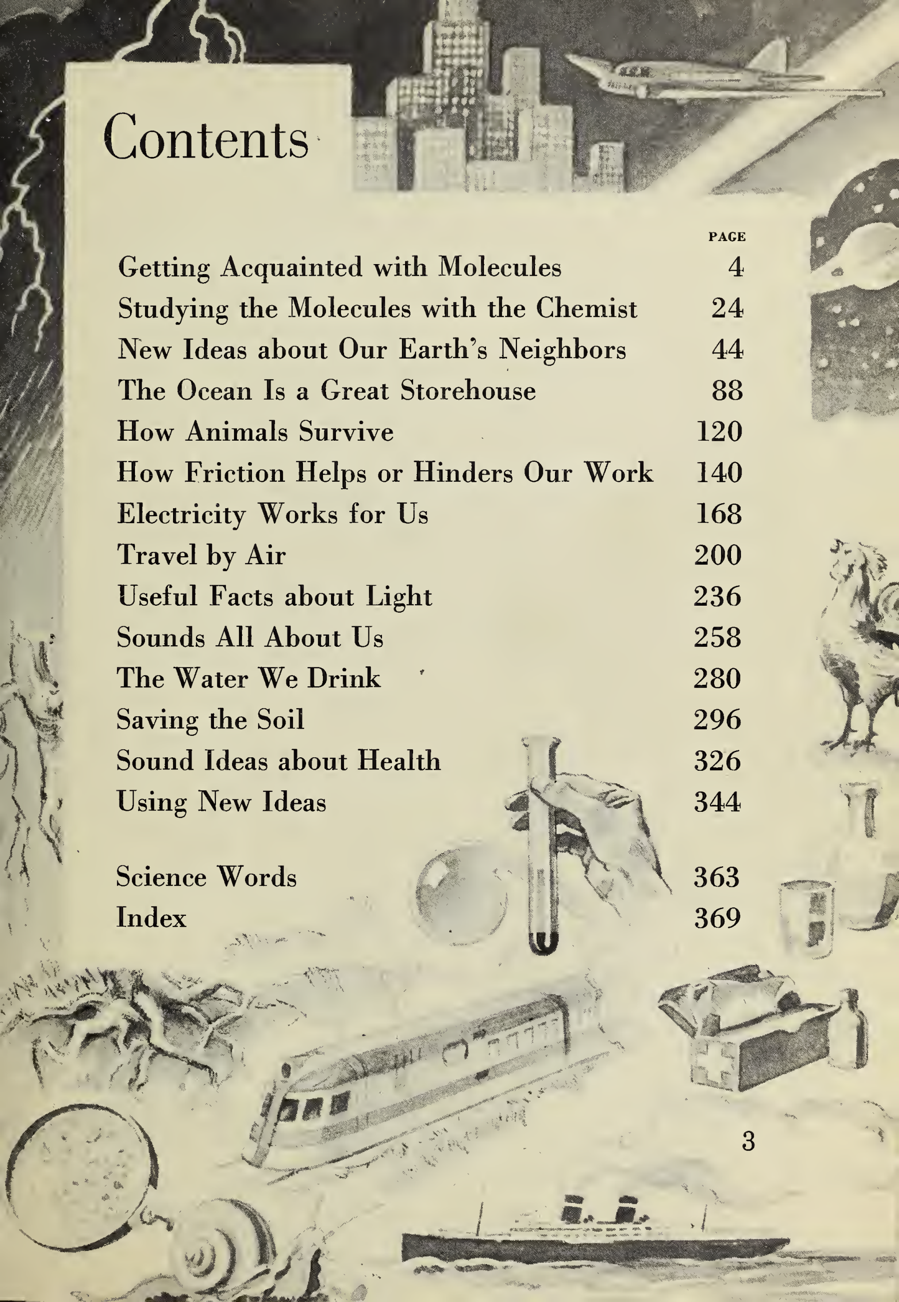

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Getting Acquainted with Molecules

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New Ideas

A good scientist works with ideas. He also has a good imagination with which to create new ideas. He may dream of homes heated in December by the stored-up heat rays of the August sun or of a rocket that will leave the earth for the moon every hour. He may imagine a time when all of us will be able to tune in on the best movies or to control rays that will heal the slightest ache or pain.

But a good scientist does not stop with an interesting idea or a dream. As soon as he gets a good

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idea he begins to plan and to experiment. Finally he adds to our scientific knowledge and thus makes his dreams come true.

Scientists have given a great deal of thought to the substances all about us. Imagine that you are sitting on the bank of a bubbling brook on a hot summer afternoon, leaning back against a big, solid rock. You look at the cool, inviting brook; you breathe the clean, fresh air. Scientists have interesting ideas about rock and water and air. They have learned a great deal about these things.

Solids, Liquids, and Gases

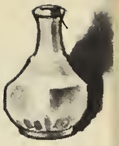
First, scientists know that all substances are solid like the rock, liquid like the water, or gaseous like the air. A few simple experiments will make it clear what these three words mean.

Let us take a small piece of rock, a cup full of water, and a bottle full of nothing but air. Place the rock in a bottle, pour the water into a bottle, and just keep the bottle of air close by.

When you place the rock in the bottle, does the shape of the rock change? No. Solids, such as rocks, have a shape of their own. They do not change their shapes when moved from one place to another.

Look at the bottle with water in it. The water in

the bottle has taken the shape of the bottle. The same thing would be true of vinegar, milk, tomato juice, or any other liquid if it were poured into the bottle. Any liquid will take the shape of the container into which it is poured.



Gases, including air, have no shape of their own. If you could color the air in your bottle red, you would see that it has no shape of its own. The red air would take its shape from the shape of the bottle.

Solids keep their own size as well as their own shape. If you should place a ruler first on a desk and then in a box, the ruler would not become larger or smaller. It would take up exactly the same amount of space in the box that it did on the desk.

If you pour a quart of water from a bottle into a bathtub, it will change its shape but not its size. You will still have a quart of water.

But if you could pour a quart of air colored red into the bathtub, the red air would fill the whole tub. Some of the air would even float out above the top of the tub. Air is gaseous, and gases have no sizes of their own; they take the size of the things in which they are placed. They spread and spread until they fill up all the space.

Solids, liquids, and gases do not look or act much alike. How many solids, liquids, and gases can you find in the pictures on pages 4–5?

When Substances Change Size and Shape

People sometimes say, "I'm so thirsty I could drink water in any shape or form." But they could not drink water in its solid form or its gaseous form. Ice and steam are water, but they are not good for drinking. One is much too hard and cold, and the other is much too hot. Those who say that they could drink water in any shape or form are mistaken.

You can watch ice change from a solid to a liquid by melting it, and then watch the water change to a gas by boiling the water. You can see both the solid water and the liquid water, but you cannot see water that has become a gas, for steam is invisible.

When water is boiling in a teakettle, liquid water forms a cloud above the steam as the steam cools. In the space between this cloud and the boiling water is the invisible steam. What do you really mean when you say, "Look at the steam"?

Milk can be a solid as well as a liquid. Usually we drink milk, but we may also eat it in some forms. Have you ever found solid milk in a bottle which the milkman left on your doorstep on a cold winter morning? Ice cream made of milk or cream is also a solid.

Butter also can change its shape and size. What

Liquids and solids

happens to butter on a warm summer day? At a high temperature, butter will become a liquid. If you want butter to keep its own shape, keep it cool. But substances much harder than butter can change their shape and size.

Perhaps you have put dry ice in a glass of water and watched it bubble. Dry ice is very, very solid cold carbon dioxide. When it becomes warm, dry ice changes to colorless carbon dioxide gas, which is like part of the air that you breathe out of your lungs.

Frozen carbon dioxide is much colder than frozen water. "Dry ice is so cold it burns," warn people who work with frozen carbon dioxide. In fact, dry ice would freeze your skin if you touched it: and freezing will hurt just as a burn will.

Try to get a square of dry ice from a drugstore so that you and your class can watch this cold solid change to a gas. You must not touch it with your hands. How can you carry it to school?

By cooling air until it is very much colder than dry ice and

then pressing it together, scientists can change air into a liquid. Liquid air looks somewhat like water but it too would freeze your lips if you tried to drink it.

If a rubber ball were placed in liquid air and then thrown on the floor, the ball would break as if it were made of glass. You know that alcohol is put in automobile radiators in winter because it does not freeze on the coldest days. But if alcohol were placed in liquid air, it would freeze solid.

Does ice seem cold when you hold it in your hand a while? Compared with liquid air, ice is quite warm. Ice is so much warmer than liquid air that it can heat liquid air and make it boil. When it boils, liquid air again becomes a gas.

Air that is solid is even colder than liquid air. Can you imagine solid air as hard as ice? Such air is rarely used except by scientists in their laboratories.

Certain solids, for example, iron and copper, can change to liquid. They are first heated in furnaces until they become very hot. When they are heated enough, they become liquids and can be poured. If the shape of a solid needs to be changed into another shape, the solid is melted into a liquid and poured into a mold. When the liquid cools, it becomes solid again and keeps the new shape.

So you see that solids, liquids, and gases can each change into the form of the others. When a solid changes to a liquid, and when a liquid changes to a gas, something very strange takes place in each case. Something equally strange occurs when a gas changes into a solid. To understand these changes, we need the imagination and knowledge of a great scientist. When scientists began to study such common things as air, water, and rock, they asked many questions before they found answers that seemed to explain what had been unknown for many centuries.

The scientists wanted to know the answers to these questions: What are simple things made of? How do they hold together? What is the difference between solids, liquids, and gases?

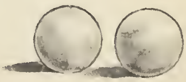
The answer to the first question is that all things are made of many very small particles. These small particles are called molecules, meaning "little masses."

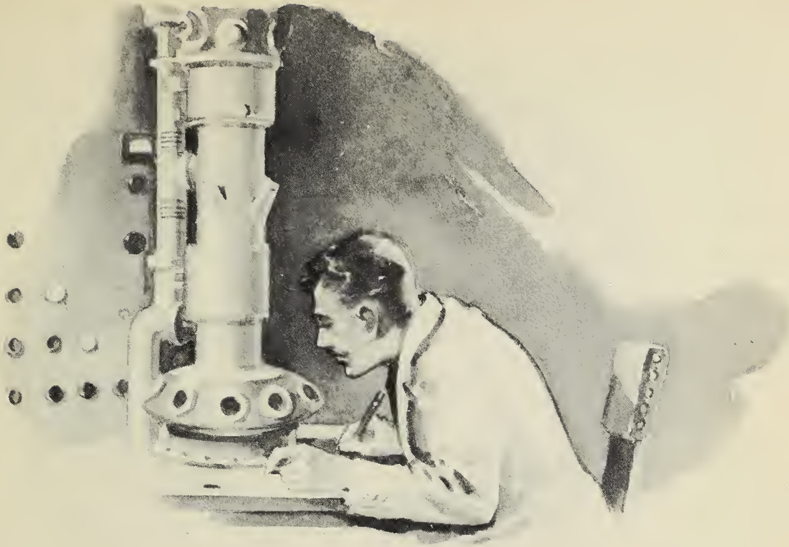
Molecules Are All About You

Have you ever seen molecules? Books, candy, roses, puppies, and airplanes are made of molecules. Fire engines, jumping ropes, and baseballs are made of molecules. The gases in the air, the water in the brook, and the viruses that cause diseases—all are made of molecules. Even you are made of molecules! In fact, all solids, every liquid, and all the gases in the world are made of the tiny particles which we call molecules.

You have seen only large masses of molecules, for it takes many, many of them to make things large enough to be seen. A molecule by itself is too tiny to be seen except with a very powerful microscope.

If a drop of water could be magnified so that it looked as large as the whole earth, the molecules in the drop of water would appear to be as large as baseballs. Think how many baseballs we would have to place together to form anything as large as this whole round world. Does your imagination help you to enjoy these interesting ideas?

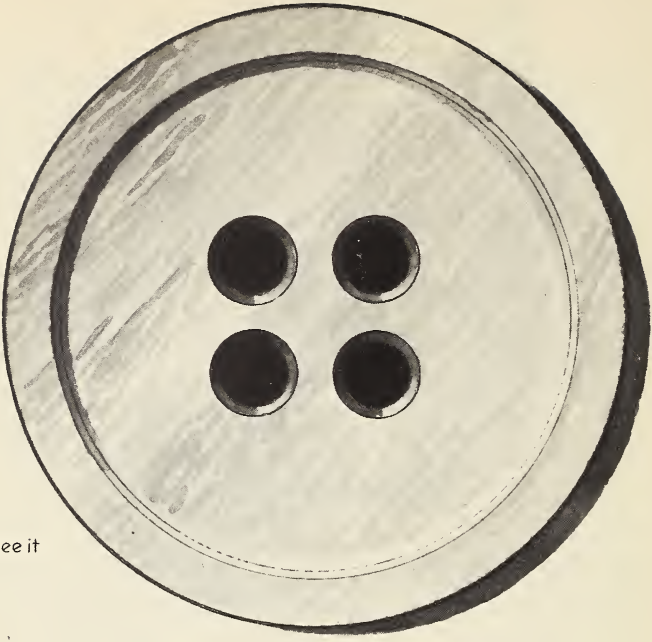




Seeing One Molecule. There are many kinds and sizes of molecules. Scientists talk about large ones and small ones. Some things are made of large molecules; others are made of small molecules; but the very largest molecule is so tiny that we scarcely have the right word to describe it.

People once said, "Molecules are so small that no one will ever be able to see the largest molecule in the world." Then along came improved microscopes which magnified more than scientists ever dreamed they could. These new microscopes can make things appear many times larger than the best microscopes could in the past. The new electron microscope magnifies things one hundred thousand times.

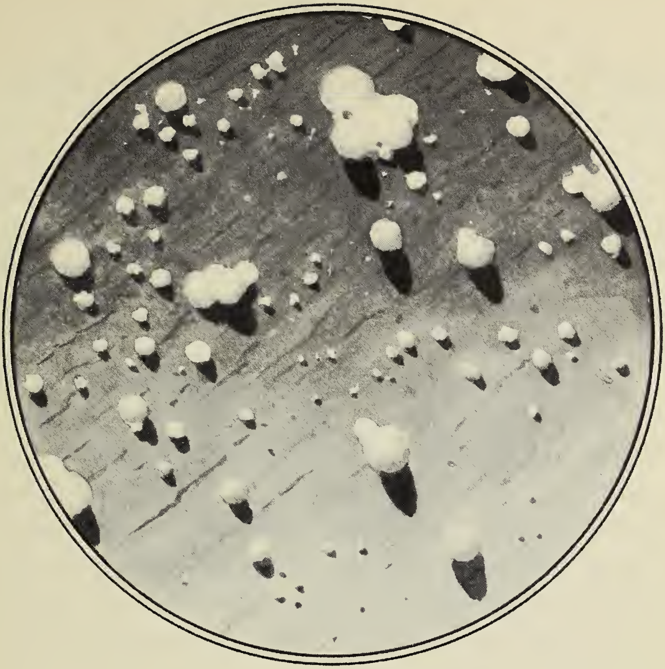
Button as we see it



Button magnified 30 times

When the tiny button at the left in this picture is magnified thirty times it looks like the button on the right.

Scientists say that with electron microscopes they have seen separate molecules. They have seen large molecules like those of the virus that causes the disease influenza. These molecules had been magnified sixty thousand times. They looked like the molecules in the picture on page 15.



Even before scientists could see separate molecules, they learned much about them. Scientists were like clever blind men using their brains instead of their eyes to learn about things they could not see. And so they put molecules to work for them even though each molecule could not be seen apart from the others.

Molecules Move. But we have only begun to learn of the interesting ideas that scientists today have

about water, air, and rock, and other substances all about us.

Scientists tell us that molecules move. If you could see the molecules in a glass of water or in an aquarium or in an open dish, you would find them darting about. They bounce back and forth, up and down, sideways, and in every direction. And they keep moving all the time.

You would find that some molecules in the glass of water travel faster than others. A very fast-moving water molecule might shoot right out of the water into the air. Then it might hit a molecule in the air and bounce back into the water. And it might escape and move among the molecules in the air. If many molecules escape from the liquid, there will be less water in the glass. We would say that the water has evaporated.

Let us put into use what we have learned. Pour equal amounts of water into two jars or dishes that have openings of different sizes. Now put them both aside for a day or two. Set them near each other in a place where they will get equal amounts of sunlight and heat. What do you suppose will happen? Can you give a reason for what may occur? Check your guess several days later by measuring the amount of water that is in each jar.

You cannot see the water molecules that bounce

out of the water, because they are too small. But so many, many molecules of water have moved out of the jar that you can easily see that part of the water has evaporated.

Nor can you see the water molecules moving in the jars. But you can see what happens when millions of them move. Fill a medicine dropper with ink and carefully place it in a glass of water. See that no ink is on the outside of the dropper. Do not stir the water, and be careful not to squeeze any of the ink out of the dropper. Let it stand in the water several hours. Watch for a change that proves to you that millions of molecules are moving about in the glass.

Scientists believe that molecules in everything are moving. There are thousands of molecules in the point of a needle or of a pin, but they are not too crowded together to move. There is enough space between them to allow them to move. And move they do. Scientists believe that the molecules in your desk are moving, that the molecules in your books are moving, and that even the molecules in this paper are moving about. But you cannot see them or feel them any more than you can see or feel the molecules moving in the glass of water.

Perhaps molecules in solids are packed together more closely than molecules in liquids. The molecules in ice are probably not as free to move as are the molecules in liquid water. Scientists also believe that molecules in solids do not move as fast as molecules in liquids.

Molecules in gases seem to move even faster than those in liquids. They dart back and forth with a speed that is greater than we can imagine. If you should take the cork from a bottle of gas colored green, the moving molecules would rise and spread through the air. After a while they would be so scattered that you would not be able to see any green gas in the bottle or in the air.

As soup boils, molecules bounce out of it just as they bounce out of water. There will be many molecules from soup darting about above the kettle. Some of them will move far away from the stove. Perhaps some molecules from onion soup have traveled to your nose as you entered the house. Maybe they have traveled so far that people in the

house next to yours could smell them. They may scatter until no one will be able to smell the onion soup. The onion-soup molecules have scattered and spread among the fresh-air molecules.

Making Molecules Move Faster. Suppose you wanted the molecules of water to evaporate from a wet towel. You could spread it out so that the molecules would have a chance to escape into the air. Or you could make them move faster by heating them. When you heat ice, the molecules move faster and faster and the ice changes from a solid to a liquid. If you heat the liquid water that is left when the ice melts, the molecules will move still faster.

Fast-moving molecules escape more easily than the slow ones; so, as water gets hotter, more and more molecules go off as a gas. Water disappears as the colorless gas molecules spread out through the air and dart about among the air molecules.

When you heat water the molecules move faster and faster as the water becomes hotter and hotter. When you freeze water, they do not travel so fast. In each of its forms—solid, liquid, or gas—water molecules travel at a different speed.

Carbon dioxide is a gas; but if carbon dioxide is made cold enough, it becomes a solid. The air around us is gaseous; but when air becomes very, very cold, it becomes a liquid. Iron is a solid; but if it is heated enough, it becomes a liquid.

When solids and liquids and gases change from one to another, they may change their size and shape. Sometimes water has a definite size and shape. If the molecules in ice begin to move faster through heating, so that water changes from a solid to a liquid, it has a definite size but no shape of its own. When water has neither special size nor shape, it cannot be seen. What is it called then?

Water may be a solid, water may be a liquid, and water may be a gas. But in all its forms, the molecules of water are moving.

The Motion of Molecules Explains Certain Facts

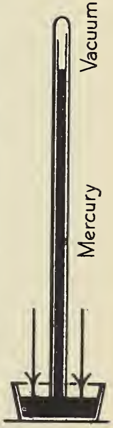
Before we leave this idea of the scientists that molecules move, we ought to see how well their explanation takes care of facts which we ourselves have seen. Here are a few facts. Study how the idea of molecules explains these facts. Does the explanation satisfy you? Why not try to answer still other questions about substances with this idea of molecules in mind?

We know that railroad rails fit closer together in the hot summertime than in the wintertime. Could it be that the molecules are moving faster and farther in the hotter weather? They seem to stretch the rail a little.

We know that mercury is held up in a barometer tube. Could it be that the molecules of the air in the tube are bouncing and pushing at the surface of the mercury exposed to it? Air pressure in the barometer may well be considered the push produced by millions of tiny blows each second. These are the blows of the molecules.

We know that air pressure is low on the top of mountains. Why? Because the air molecules are not packed so tightly together, and they travel more freely and farther. They push against a surface less often; so the mercury in a barometer tube falls.

We know that if we hold a silver spoon in hot tea or coffee we feel the spoon grow hot. Could it be that the molecules in the spoon are heated in the liquid, move faster, bang the molecules next to them



A simple barometer

and increase their speed? Finally the molecules at the end of the spoon are so hot that we drop it.

As you study the pages of this book, you will find that this idea of the scientists—that molecules move—will often help to explain a troublesome question.

THINGS FOR YOU TO THINK ABOUT

1. Imagine a room in which tennis balls are flying about in all directions. Some bounce on the walls, some strike the ceiling, and some bounce on the floor. Some bump into each other and bounce away in the opposite direction. Some may even fly out the window. The molecules in the air in your room are somewhat like these tennis balls. Tell how they are different.

2. Molecules do not always escape from solids the way they do from liquids. Explain why some solids have no odor.

3. Is frozen iron cold?

4. Write the number 189 and put 23 zeros after it. There are more than this number of molecules in a pint of water. How long do you think it would take you to count these molecules?

5. Tell why your clothing will dry faster in front of a hot stove than in a cool place.

6. Why does ink in an open inkwell become thick?

7. Tell why it is better to water the lawn after sunset than while the sun is shining.

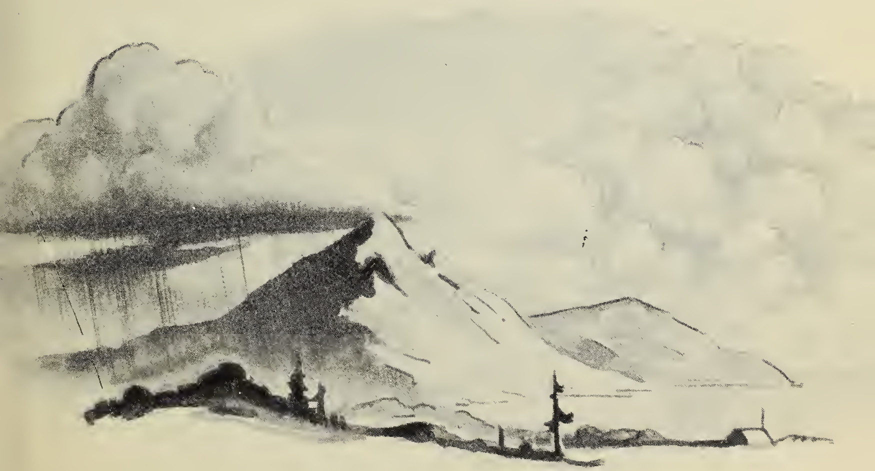
8. Why can a friend usually tell when there is a cape jasmine or a gardenia in your home?

9. If butter is not covered, it will taste like other foods in the refrigerator. Explain why.

MORE THINGS TO DO

Find the places in this picture where there may be water molecules. What is happening to their speed?

1. As the water melts on the mountainside?
2. When the water evaporates from the lake?
3. As the clouds form?

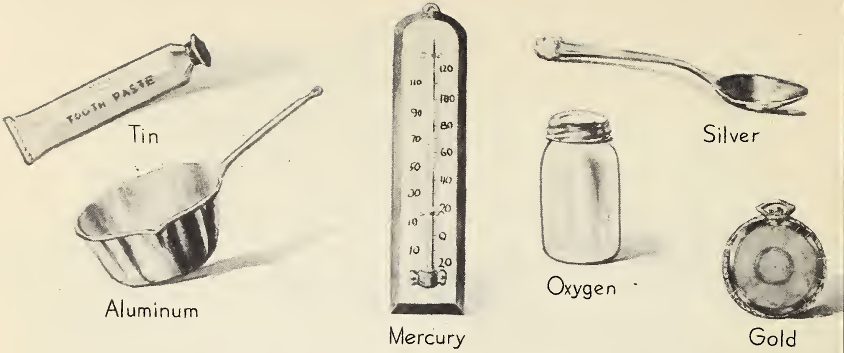


Studying the Molecules with the Chemist

Elements and Compounds

The moving molecules we have just read about are not all alike. A molecule of water is like any other molecule of water, but it is not like a molecule of rock. It would take many books to describe the many different kinds of molecules that we know anything about.

There are millions of different substances, but it would not take many pages to describe what elements they are made of. For of all the thousands and thousands of substances chemists have examined, they have been able to find less than one hundred different kinds of elements making up all of these substances. In fact scientists believe that everything in the world is made of one or more of these elements. Therefore, elements might be called the building blocks of the world. Postage stamps, dogs, bananas, shoes, grass, air, rocks, and human beings, all are made of some of these substances.



An Element Is Made of One Kind of Molecule. Do you know the name of an element? Each thing that we have just named is made of several different kinds of molecules; therefore we know that they are not elements. Perhaps you have heard of oxygen. Since oxygen contains only oxygen, we know that it is an element.

It would be hard for you to prove that any substance is an element or how many elements it had, but chemists have ways of proving it. You might begin by guessing about salt, water, rock, gold, and iron. Are you sure that any one of these substances is an element? Let us take table salt. With the help of electricity, chemists have been able to change salt into two different substances. We know, then, that there are two different elements in salt.

Do you know if water is an element? Chemists have been able to get hydrogen and oxygen, two very different elements, from water.

How about the rock you leaned against when you were on the bank of the brook? With your naked eye you can see many particles in it, for there are different kinds of minerals in most rocks. Neither salt nor water nor rock is an element.

Iron? If iron is pure, it is an element; but there is practically no pure iron in use in your home. Gold? Yes, gold too is an element. But there is not a ring in your home that is all gold. Copper, carbon, silver, mercury, hydrogen, and helium are a few of the elements, out of which the world is made. Chemists cannot divide a single one of them into more than one element, as they can salt or water. They can change them only by adding something to them or by breaking them apart with an atom smasher.

The Chemist's Alphabet. Sometimes, instead of being called building blocks, the elements are called the chemist's alphabet. They are like the letters making up a word. The word "fun" is a combination of letters. Let us take it apart. The f, u, and n are the parts of the alphabet that make up the word "fun." Take the word "sunshine" apart. How many different letters are in it? The letters n and s appear twice.

The chemist calls a combination of the parts of his alphabet, or elements, a compound. Sometimes elements appear more than once in a single compound.

Carbon, hydrogen, and oxygen are three elements that are able to arrange themselves in many different ways. In fact thousands of different compounds are formed from these three elements. Some of these elements are found in each object shown on this page.

A few of the compounds of carbon, hydrogen, and oxygen are familiar to you: sugar, vinegar, starch, alcohol, gasoline, turpentine, and lemon juice. They are all made of different amounts of these three elements arranged in special ways. Compounds made of the same elements can be very different. Compare the color and odor of the ones named above.

We know that there are twenty-six letters in our alphabet and almost one hundred elements in the chemist's alphabet. Certain dictionaries contain half a million words, all of which are made from different combinations of the twenty-six letters. Think how many different things can be made then by using all the elements. Not all elements will combine with all others, but thousands of compounds can be made from the elements that will combine.

In their work on atomic energy scientists have discovered new kinds of elements never before found in nature. Perhaps they will discover others. We can be sure, however, that they will produce many new compounds with the ones that they already have.

Mixtures

Let us recall the rock we leaned against by the side of the brook and the air we breathed at that time. When chemists studied the molecules in these three kinds of substances, they discovered many interesting things. They discovered that two samples of air might have different kinds of molecules in them. They also found that if two pieces were chopped from different parts of a rock the same substance was not always found in each piece. Rock and air are not compounds, because compounds are made of exact amounts of elements arranged in a special way. Rock and air are mixtures.

When you were a little child, you made mixtures. Soil and water made a mixture for your mud pies. Cinnamon and sugar made a mixture for your toast. Since you have grown older and perhaps own a chemical set, you have made other mixtures with sugar, salt, sand, sulfur, and carbon, and you have used

different amounts of these substances in making mixtures. You were experimenting. You wanted to see what would happen by combining these substances.

When your mother bakes a cake, the batter, a mixture, is carefully prepared. Your mother follows a recipe so that she will not use too much of anything that the recipe calls for. When baked, the materials have mixed with each other to make a cake. A cake is a mixture of several compounds.

Do you know what molecules are mixed to form the air we breathe? There are molecules of oxygen. Then there are molecules of water vapor. Besides oxygen and water vapor there are small amounts of carbon dioxide which have been breathed into the air by animals and plants. Much larger amounts of nitrogen are in the air. At different times these three gases in the air differ in amount. Can you figure out when there is more water vapor in the air than usual? Can you suggest where you might find less oxygen? If the air were a compound, these differences in amount could not occur.

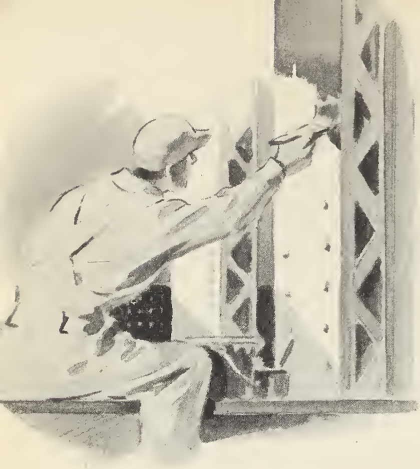
It is possible to have many kinds of mixtures. Elements can mix with other elements. They can also mix with compounds. And compounds can mix with compounds. Could you possibly count all the mixtures that can be made? Do you understand now why there are so many things in the world even though there are less than one hundred of these building blocks, or elements?

Some Interesting Facts about Elements

Oxygen, the Most Plentiful Element. Oxygen is a part of almost everything you touch. But you cannot see nor taste nor smell it. Oxygen in the air is mixed with other gases. The oxygen you breathe combines with compounds in your body to form new compounds. Oxygen is a part of the water you drink. We even find oxygen in rocks. In fact you would have a difficult time if you tried to find a place or a thing that has no oxygen. There is more oxygen in the world than any other element.

Oxygen combines with many other elements to form compounds. When iron combines with oxygen, which it gets from air, it forms the compound rust. Does rust look or feel much like iron or oxygen?

In a similar way, lead combines with oxygen to form a bright-orange compound which is called red

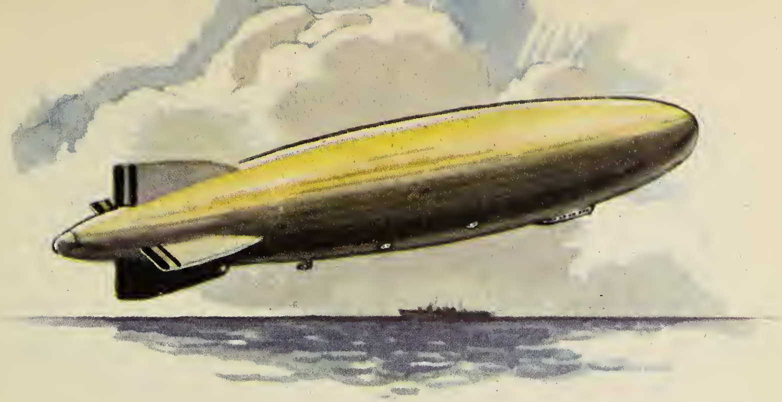


lead. Red lead is used in certain paints. Perhaps you have seen painters using this lead-and-oxygen compound on fences and bridges. This compound protects iron from combining with the oxygen in the air, and thus prevents the compound rust from forming.

Oxygen combines with hydrogen, another element, to form water. If a larger amount of oxygen is combined with hydrogen, it becomes hydrogen peroxide. Perhaps your mother has some of this liquid in a brown bottle in her medicine cabinet. You have probably used it at some time on a cut.

Oxygen combines with nitrogen to form five different substances. You probably know only one of these. It is called laughing gas, because it produces laughter after a certain amount of it is breathed. Sometimes dentists use laughing gas to make people sleep during short operations. Although we cannot see nor smell nor taste oxygen, we can use it and make it work for us. It shows itself in results.

Hydrogen, the Lightest Element. When hydrogen is not combined with any other element, it weighs



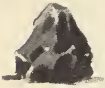
less than anything else in the world. Circus balloons are sometimes filled with hydrogen. If the string of a hydrogen balloon is not held tightly, the balloon will float away high into the air. If your balloon bumps against the ceiling, the hydrogen can hold it there several hours. After a while most of the hydrogen will leak through the rubber into the air. You will not be able to see or smell the hydrogen, but when the balloon sinks, you can be sure that most of it has already leaked out.

Now you can understand why large dirigibles filled with hydrogen can carry people through the air. The hydrogen in the dirigible is lighter than the air outside of it.

Helium, an Inactive Element. Helium has been called a lazy element, because it will not combine with anything to form a compound.

Even though helium is heavier than hydrogen, it is much lighter than air. Many dirigibles that carry people through the air are filled with helium instead of hydrogen. Since helium will not burn, it is much safer to travel in a dirigible filled with helium than in one filled with hydrogen.

Mercury, a Heavy Element. The silvery material used in some thermometers is the beautiful element mercury. When mercury is heated in oxygen, it combines with it. The result is a reddish-orange powder, which is different in many ways from the heavy, silvery liquid, mercury, or from the invisible gas, oxygen.



Carbon and Carbon Dioxide. You probably know that coal is a form of the interesting element carbon. That the diamond, clear and sparkling, should be made only of this element is amazing.

When we burn coal, the compound carbon dioxide gas is produced, among other things. This is a heavy gas, much heavier than air. Carbon dioxide is very different from the hydrogen and the helium gases we studied earlier. Let us attempt to make some of it. We do not get pure carbon dioxide gas if we burn coal to make it.

Now let us try to make carbon dioxide by a different method. Put one tablespoonful of baking soda

into a half-pint bottle or jar that has a stopper. Pour some vinegar into the bottle and place the top on it lightly. It is easy to see that something is happening. Gas bubbles of carbon dioxide are escaping from the mixture. Some of the original molecules have been changed and new molecules formed.

This heavy gas can be poured by carefully tilting the bottle in which the gas is being made. Even though you cannot see it, you will find that it is flowing out and downward if you pour it over a lighted candle. Be sure not to pour the liquid out of the bottle. What happens to the candle? Make more of the gas and pour it into another bottle. Drop a lighted match into this bottle. What happens?

From these experiments can you see that carbon dioxide is certainly different from hydrogen and from oxygen?

Fun with Substances

You do not need to own a chemical set in order to have fun with chemicals and to learn about them. Your mother uses chemicals in her kitchen and also has them in her medicine chest. You can probably find the chemicals you need for your experiments in the kitchen or bathroom of your home. But because of the danger in using certain chemicals you should ask an adult whether the experiment you plan is safe.

Here are a few interesting chemical changes that you can safely try. Epsom salts and household ammonia mixed together will give you a surprise. Washing soda and lemon juice when mixed will bubble and fizz. Even striking a match starts a complete chemical change. The compounds in the head of the match do not look like the black carbon that is left after the flame has died out, do they?

Your body is a chemical laboratory. Oxygen taken into your lungs with air burns the food that the blood in your body is carrying. Before food can be carried by the blood, chemicals must change it into different kinds of molecules.

When one substance is changed to another substance, you can be sure that the elements or combinations of elements have acted in the correct chemical way. It is wonderful to be able to understand how they change and why they change. Some of you may decide even now that you would like to be chemists. Someday you may make useful new combinations with the parts of the chemist's alphabet.

Searching for Elements

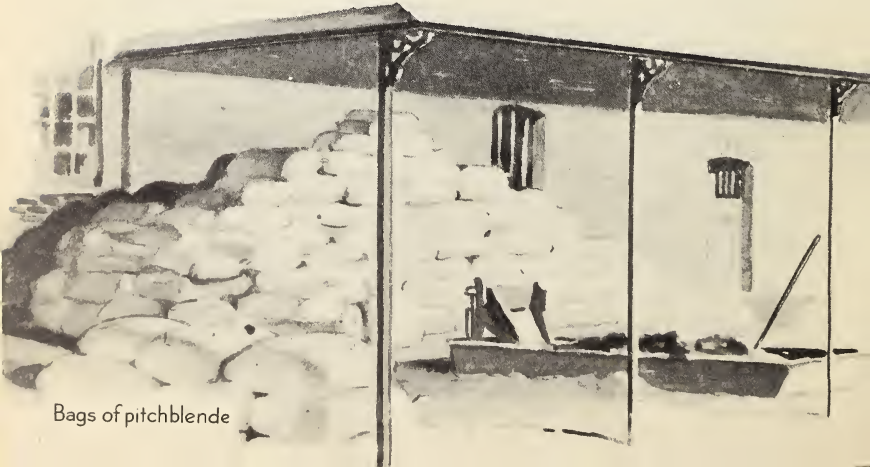
Since the beginning of history, the elements gold, silver, copper, iron, carbon, tin, and lead have been known to men. At first people did not think of them as elements, but they learned to use them and to combine them with other elements.

How many elements can you now name? Most people cannot name more than a dozen. In fact there are many people who have never heard the names of more than thirty elements. Certain elements have strange names, like dysprosium and gadolinium. They sound like words from a foreign language. As yet only small amounts of these two elements have been found, and little use has been found for them.

Even though it is rare, radium is a very important element. No one knew that radium is an element until about fifty years ago. In fact no one knew that there was radium on the earth.

Radium has been found in the ground in a bluish-black ore called pitchblende. For hundreds of years silver miners threw this ore away and thought of it as a nuisance.

After years of careful work, Marie and Pierre Curie discovered in pitchblende a new element, which they named radium. It took four years of hard work on huge piles of pitchblende for the Curies to collect enough radium to be able to weigh it. Even with modern methods, it takes tons of chemicals and a great deal of work to separate small quantities of radium from the ore.



Bags of pitchblende

The Curies at work

In their work on radium the Curies used the pitchblende of France. Since that time men have found it in the Belgian Congo and in Czechoslovakia. Not long ago radium was discovered in pitchblende under the Arctic ice and in the snows of northern Canada. Small amounts have been found in another kind of ore that is mined in Colorado and Utah.

Even though radium has been found in several parts of the world, it is still very rare. At one time an ounce of radium was worth as much as a ton of gold. As more radium has been discovered, the price has been lowered, but it is still one of the most expensive substances in the world.

Radium is so valuable and helps us so much that scientists work to recover as little as one hundred-millionth of a gram. A nickel weighs five grams. So an amount as small as one hundred-millionth of a gram is beyond our power of imagination. But now that we know how rare and important radium is, we can understand why it is so valuable.

Few people have ever seen the silvery white metal in its pure form; that is, when it is an element. Today radium compounds are used in hospitals and factories.

People who work with these radium compounds must be protected from their rays by lead aprons that cover almost the entire body and by gloves made of lead and rubber. If they were not so well protected, they would be severely burned.

New Compounds of Elements

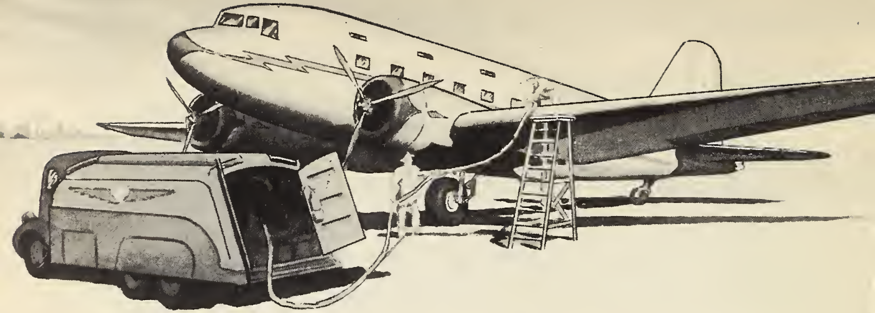
Many of the materials which we use today are combinations of elements which no one would have dreamed could be combined until a few years ago.

As scientists learn new uses for elements and their compounds, new comforts are added to our lives. The picture shows the result of several combinations of elements.

In recent years scientists have combined elements in new ways to form materials for clothing. Milk was used in making the material for this boy's suit. The girl's dress was made from the elements in coal, air, and water. The lucite used in the bowl and ornaments is a product of the chemist's test tube. Without the work of chemists, we would not have motion pictures, rayon, or cellophane. Can you name other things that we would not have?

Chemists Help Us to Use New Ideas

Chemists are somewhat like Aladdin, who went about the streets of Baghdad trading new lamps for old ones to recover his wonderful lamp. Our magazines newspapers, billboards, and radio tell us how scientists are changing materials which we once considered worthless into useful articles. Peanut shells, sawdust, grain husks, grass clippings, once thought worthless, are now being put to good use. Many materials once thrown on the scrap piles of farm and factory are now of value because chemists have made new compounds. Thousands of these compounds



have been produced because chemists have continued to arrange elements in new ways. Many of these compounds have been made during your lifetime. For example, the drug sulfanilamide, which has helped doctors to save many lives in the last few years, has been discovered since you were born. Dyes that make our world more colorful are being improved each year by the use of new compounds. Improvements made in gasoline in the last few years have helped our automobiles and airplanes to go more safely from one part of the world to another.

It would be difficult to name all the things that have been improved recently by chemistry. And still there are better things to come from the chemist's laboratory.

MORE THINGS TO DO

1. The new element plutonium was discovered by the scientists who worked with atomic energy. Watch for news about this element in newspapers.

2. Look for "dysprosium" and "gadolinium" in your dictionary. What do you find?

3. If you have a chemical set, bring it to school when you can perform a simple experiment. Explain what happens.

4. Find out from a large dictionary or an encyclopedia something about these elements: chlorine, sodium, iodine, mercury, and tin. Are these elements alike?

5. Make a list of chemical changes in which new things are produced. What happens when a match burns? What happens when water boils? What happens when steam cools?

6. Look in some science and trade magazines for pictures of man-made molecules, as in cellophane, nylon, rayon, tenite, lucite, Bakelite, and glass. What materials do these new materials replace? In what ways are the new materials better than the old ones? In what ways are the old ones better?

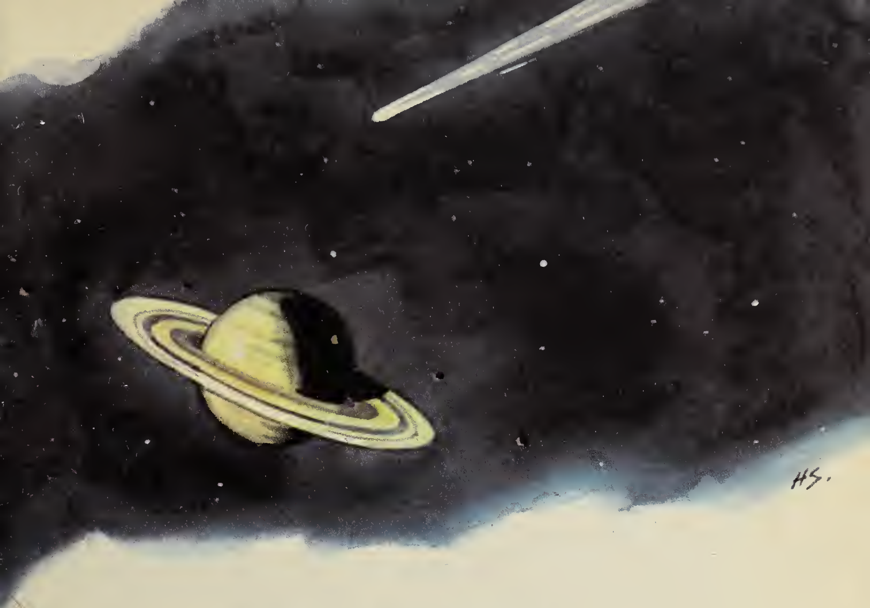
WHAT DO YOU THINK?

1. Do you know why people sometimes call chemists "pioneers of plenty"?

2. How has the work of chemists helped you?

3. Does the chemist do more than make new substances? What else does he do?

New Ideas about Our Earth's Neighbors



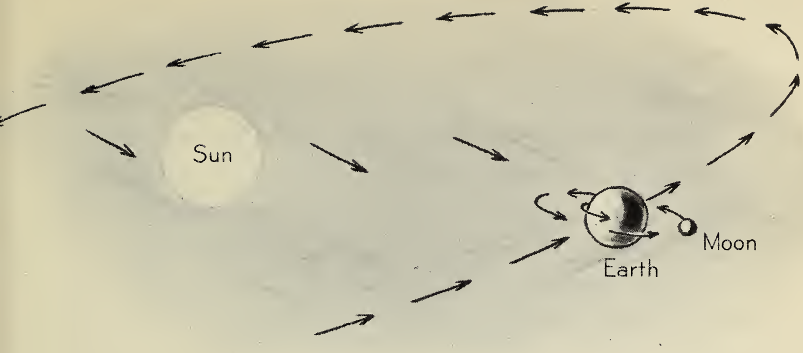
Looking into Space

With the chemist we have been studying the tiny building blocks of our world. We have had to use microscopes and to be very careful in our methods of measuring such tiny particles. But now let us turn our eyes away from the earth and its elements, and look far off at the giant heavenly bodies.

For thousands of years scientists have asked questions about the earth and also about its neighbors in space—stars, planets, comets, meteors. Although we now know the answers to many of these questions, still there are many questions yet to be answered.

Traveling on the Earth. Have you ever flown in an airplane? You probably knew when the plane left the ground; but once you were up in the air and the plane was traveling smoothly along with only empty sky around you, you may have wondered whether you were moving at all. It was difficult to know whether you were moving, because the plane itself was traveling with you and at the same speed. If there had been some object outside with which to compare your speed, you would have known you were moving.

Or maybe you have traveled on a train which for a while ran next to another train going in the same direction and at the same speed. The people in the other train stayed in the same position opposite you. The advertisements in the other train seemed to stand still as you looked at them. Because both trains were moving in the same direction and at the same speed, neither one seemed to be moving.



The Earth Is Traveling. When you look out of the window at home or at school, do you seem to be moving? Of course not. Yet an airplane or a fast train really moves slowly compared with the speed at which you and your house or school are moving through space. The trees, the ground, the house next door, are all moving along with you—all on the earth which is itself moving. You would not know this if there was not something out beyond the earth by which you could judge your own motion.

The earth travels in several different directions at once. It spins on its axis like a top, a motion which causes day and night. It travels around the sun at a speed of 18½ miles a second, and in a year's time gives us our four seasons.

But, in spite of all these fast motions, it is hard to realize that the earth and everything on it are moving. This is because all the animals, plants, mountains, oceans, and even the atmosphere, travel along with it. Then how can we tell that we are moving?

During the day the sun appears in different parts of the sky at different hours—in the east at sunrise, high in the south at noon, and in the west at evening. Early astronomers believed that the sun and all the other heavenly bodies moved around the earth every 24 hours.

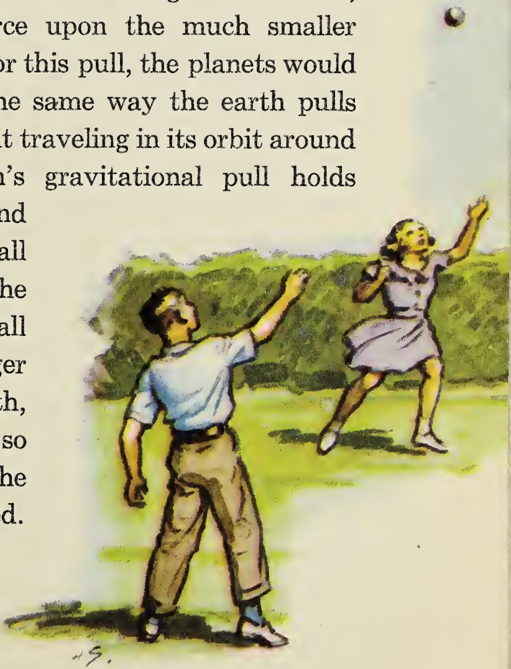
Today we know that the earth spins toward the east at a rate of 700 miles an hour in middle latitudes. As we travel along on the earth's surface, the heavenly bodies appear to move in the opposite direction. In the same way, when you travel by train you see the trees and houses outside appearing to travel in the opposite direction. Now we know that by watching the sun we can actually become aware of our own motion as the earth spins. The sun only appears to move westward across the sky.

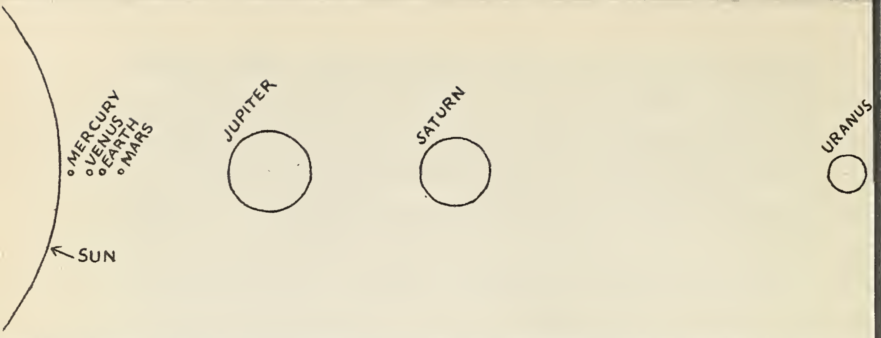
Since the earth travels around the sun at the rate of 18½ miles a second, in one minute we journey more than 1100 miles. How far do we travel in an hour? in a day? The earth is indeed a fast traveler.

The Sun's Family

The earth is not the only body that travels around the sun. With it are eight other planets, fellow members of the sun's family. The word "planet" comes from the Greek word which means "wanderer." Stargazers noticed long ago that these wandering bodies moved around in the sky against the fixed pattern of stars and constellations.

Planets Travel in Definite Paths. The planets are held in their paths around the sun by a mysterious force, called gravity. We know that each little bit of matter in the universe attracts or pulls upon every other particle of matter. The pull of large bodies is of course greater than that of smaller ones. Because the sun is so large and massive, it pulls with great force upon the much smaller planets. If it were not for this pull, the planets would fly off into space. In the same way the earth pulls upon the moon, keeping it traveling in its orbit around our planet. The earth's gravitational pull holds you to its surface, and pulls back to it the ball which you throw into the air. Of course the ball also pulls on the larger and more massive earth, but the ball's pull is so much less than that of the earth, that it is not noticed.

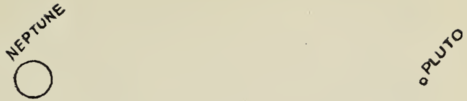




Remember, then, that large massive bodies exert a greater pull than small bodies containing little material. But each object in the universe, no matter how small, pulls on all other objects to some extent.

Two of the planets are nearer the sun than the earth is. The six planets that are farther from the sun than the earth make longer trips around the sun than the earth does. These planets travel so fast that they are not pulled into the sun by the sun's gravitational pull. The Romans called the sun "Old Sol" after their sun god. Because "Old Sol" is the center around which the planets move, the sun's family is known as the solar system.

A Chart of the Solar System. Perhaps you would like to make a chart of the solar system. Use a strip of paper or several pieces of paper tacked or pasted together along the side of your schoolroom.



It must be 17 feet long. Even on this long paper, you must make the sun less than a billionth as large as it really is. Draw a slightly curved line at one edge of the paper to represent the rim of the sun. To know where to place the planets and how large to make them, you will have to study these tables. The first one shows the sizes to make the circles representing the planets on your chart. The diameters of the circles for your chart are millions of times smaller than the diameters of the real planets.

PLANET	ACTUAL DIAMETER	SIZE OF CIRCLE ON CHART
Mercury	3,100 miles	¼ inch
Venus	7,700 miles	between ½ and ¾ inch
Earth	7,913 miles	between ½ and ¾ inch
Mars	4,216 miles	between ¼ and ½ inch
Jupiter	86,700 miles	7 inches
Saturn	71,500 miles	5¾ inches
Uranus	32,000 miles	2½ inches
Neptune	31,000 miles	2½ inches
Pluto	6,000 miles	½ inch

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The distances between the planets and the sun must be even a smaller fraction of their real distances. There would not be room enough to put the planets on your chart if these distances were not made many billions of times smaller than they really are.

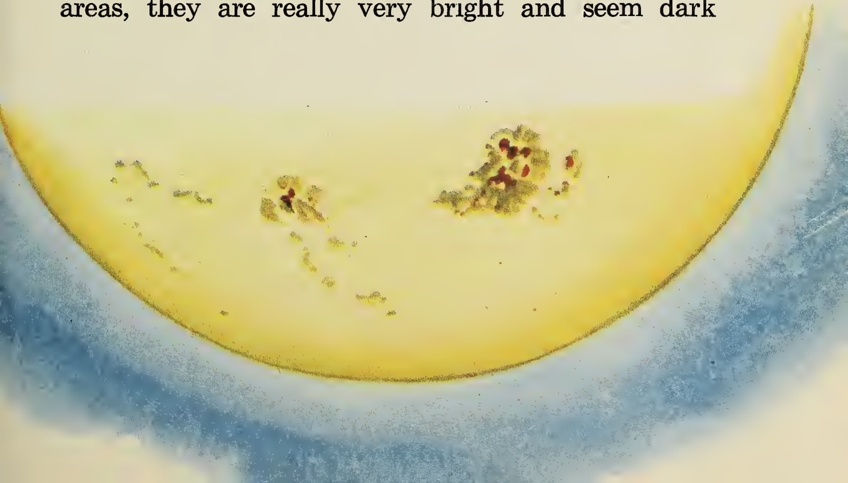
PLANET	MILES FROM SUN	DISTANCE ON CHART FROM SUN TO CENTER OF PLANET
Mercury	36 million miles	2 inches
Venus	67 million miles	3½ inches
Earth	93 million miles	5 inches
Mars	141 million miles	7½ inches
Jupiter	483 million miles	2 feet 1 inch
Saturn	886 million miles	3 feet 11½ inches
Uranus	1,782 million miles	7 feet 11 inches
Neptune	2,793 million miles	12 feet 6 inches
Pluto	3,700 million miles	16 feet 7 inches

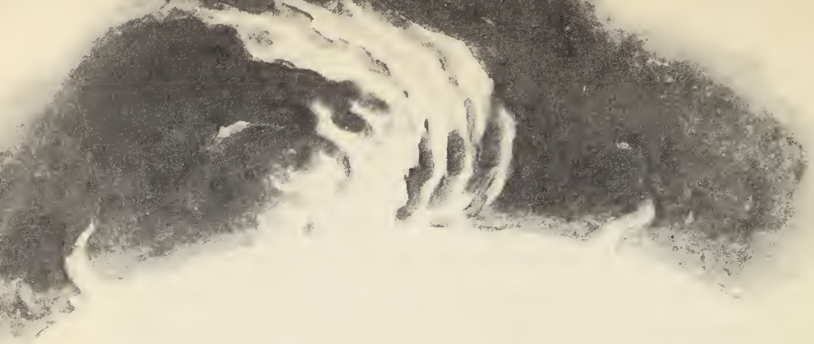
The Sun, Our Star

To build a ball as large as the sun you would need to use more than a million balls the size of the earth. The sun weighs much more than three hundred thousand times as much as the earth. To secure heat equal to the heat of the sun, we should have to use 8 trillion tons of coal every second. This is enough coal to supply our country for more than a thousand years. Such figures as these are difficult to imagine. It is even more surprising to learn that there are many stars much bigger and brighter than the sun. In fact astronomers, scientists who study the heavens, tell us our sun is only a middle-sized star.

The Sun Is Very Hot. The star which we call the sun is 93 million miles away from us. Since light travels about 186,000 miles a second, light from the sun takes a little more than eight minutes to cross the space between the sun and the earth. The sun, like all the other stars but unlike the planets, produces its own light. It is so hot at the sun's surface that anything, even the hardest and most solid of objects, would be changed into gas there as quick as a wink. At the sun's surface the temperature is about 10,000 degrees Fahrenheit; at its center the temperature is perhaps 40 million degrees.

Sunspots. If we need to look directly at the sun, we must be certain to use very heavily smoked glass, for if we do not the sun's bright light will blind us. Through the smoked glass we might see now and then black spots on the surface of this nearest star of ours. Although we see these sunspots as dark areas, they are really very bright and seem dark





only because the rest of the sun is brighter. Sunspots look dark because they are cooler than the rest of the sun's surface. We do not know the cause of sunspots, but we do know that these dark regions are magnetic storms on the sun. They act somewhat like terrific cyclones in the hot gaseous body of the sun.

Some scientists explain these spots as being caused by explosions from within the sun. Huge quantities of gases shot out by the explosions cool as fast as they reach the sun's surface.

It is hard to believe that storms on the sun, more than 93 million miles away from us, can affect our life on the earth. Yet they can cause magnetic storms on earth which upset the magnetic compass and make it point in the wrong direction. Sunspots can also affect radio powerfully. When a number of large sunspots appear at one time, there is usually trouble with the sending of telegrams, radiograms, and cables.

The sun is interesting in other ways. Sometimes jets of incandescent gas nearly a million miles high and bright orange-red in color are seen streaming away from it. These are called prominences, and appear like the jets in the picture opposite. During a total eclipse when the moon hides "Old Sol," a gorgeous corona appears like a pearly-gray halo around the sun.

The Other Members of the Family

Do you think that our earth is a good place on which to live? Or do you complain because it rains when you want to play out of doors? Perhaps you are one of those who wish it would rain oftener. During the summer we often complain of the heat, and during the winter we wish that the weather were not so cold.

Perhaps you have wondered whether one of the other planets would be more to your liking, with exactly the right amount of rainfall and an even and pleasant climate all the year round. You may even wonder whether people or animals or plants live on any other planet.

Suppose we find out as much as we can about the other members of the sun's family. As we read let us imagine the kind of life, if any, that might be present on each planet.

Mercury, the Smallest Planet. First let us see whether you would like to live on Mercury. Mercury's name fits it well. The Romans named it for the messenger of the gods because, like that messenger, Mercury is swift. Since it travels over a shorter path than the earth and at a greater speed, Mercury completes a journey around the sun in less time than the earth does. As Mercury whirls around the sun it moves at a speed of 30 miles a second. This is almost twice as fast as the earth travels.

Birthdays would be just eighty-eight days apart on this planet, and you would be four times as old there as you are upon the earth.

Since the same side of this planet always faces the sun, day lasts on that side forever; and year after year it is night on the other side.

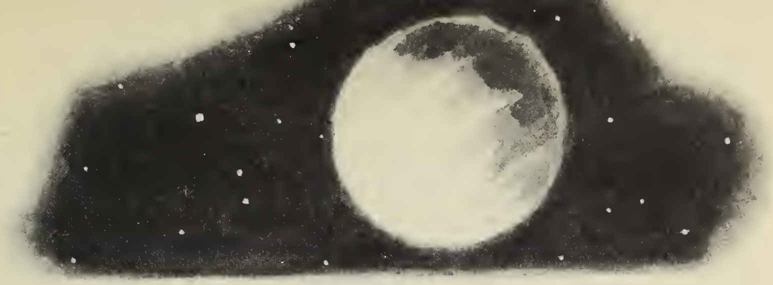
Sometimes you are much too warm when the hot rays of the sun strike the earth, but even so you are much more comfortable than you would be on Mercury. On the daytime side of Mercury the temperature is about 770 degrees, which is hot enough to melt tin and lead. Boiling water would seem cool in comparison. On the planet's other side, where it is always dark night, it is so cold that you would freeze to death immediately. It is probably about 459 degrees below zero there. By now you know that you much prefer to stay right where you are, on the good planet Earth.

Furthermore, so far as we can tell, there is neither air nor water on Mercury. Probably an ocean of air once surrounded Mercury, just as one surrounds our earth. Mercury's mass is so small that its gravitational pull is not strong enough to hold an atmosphere to it; the air molecules have escaped into outer space. Under these conditions do you think that there can be life on Mercury?

Venus, Our Twin Planet. Venus, the planet which travels around the sun in a path between Mercury and the earth, is our nearest fellow planet. It may come as close to us as 26 million miles. Venus is sometimes called the earth's twin, because it is nearly the same size. It is about four fifths as massive as our planet. Venus is not an identical twin, but it is certainly like the earth in many ways.

Perhaps you have seen Venus as an evening or a morning "star." People called it a "star" long before they knew about planets. Venus is a beautiful silvery-white color. Sometimes you can see it in the western sky after sunset, and at other times in the east just before the sun rises. Because Venus travels around the sun it is sometimes to the east of the sun and sometimes to the west. Venus is brighter than any other heavenly body except the sun and the moon.

Since Venus is the planet nearest the earth, you might expect astronomers to know more about it than they know about other planets. Actually, the layers of clouds that surround Venus are so thick that no one has been able to see through them.



Because Venus is hidden from us by these heavy clouds through which we cannot see, no one knows how long a day lasts there. Many astronomers believe that Venus spins so slowly that the period between one sunrise and the next lasts about as long as one month on earth.

Since no water vapor has as yet been discovered in the atmosphere, it is possible that the clouds of Venus are not at all like the ones in our sky. Certain astronomers believe that they are composed of solid material very much like the plastics so commonly used on the earth today. This is not definitely known, but it is certainly an interesting possibility.

The temperature of Venus is much more like ours than is Mercury's. Even though the nights are long, it is only 9 degrees below zero on the cold, dark side of the planet. The temperature on the daytime side varies between 120 and 140 degrees Fahrenheit. If you have ever lived on a desert, you may have been as warm as the temperature on Venus. Certainly life as we know it could exist at these temperatures.

Although astronomers have found no water vapor or free oxygen in the upper clouds of Venus, that does not tell us the whole story. Below the level that we can see, conditions may be quite different. There may be plant life on Venus, because carbon dioxide is found in the clouds.

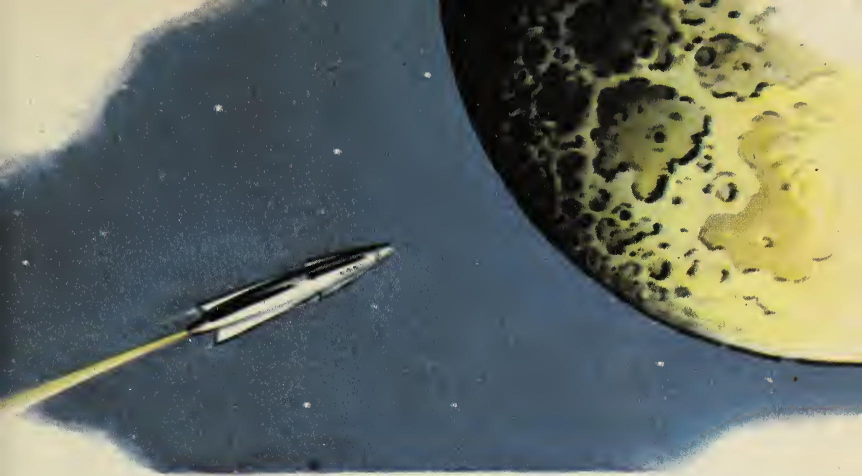
Our Earth and Its Moon. The third planet from the sun is the earth. We know that the earth is 93 million miles from the sun, and that it takes one year to journey around the sun, our nearest star. During each one of the 365¼ days which make up a year on the earth, our planet spins all the way around once in a period of twenty-four hours.

With oxygen in the air for us to breathe, a proper climate for the existence of life, and food and water at hand, our earth makes a good home for us.

Our nearest neighbor in the sky is the moon. It travels around the earth in much the same way that the earth travels around the sun. The moon is at an average distance of 240,000 miles from us.

On your chart of the solar system add a circle as near the earth as you can place it. The diameter of this circle should be one fourth that of the circle used for the earth, since the moon's diameter is about 2000 miles and that of the earth is about 8000 miles.

Because the moon is our nearest neighbor, many

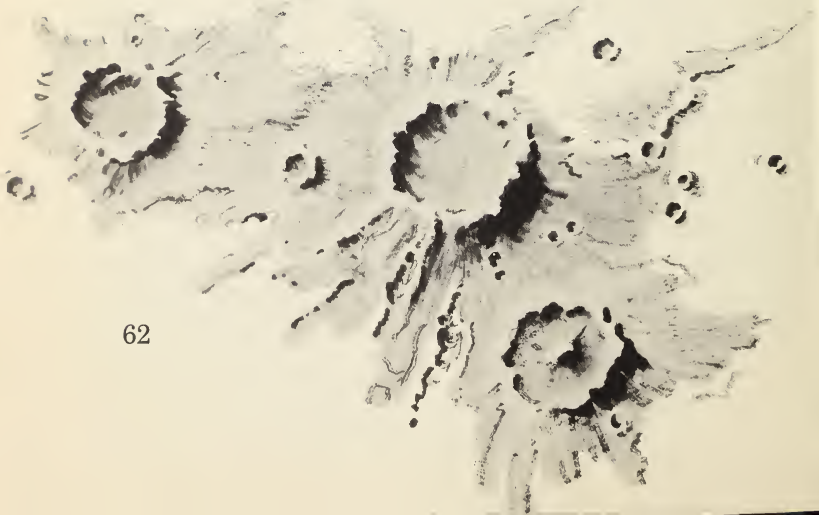


people have wondered if we might someday visit it. If a rocket could be sent to the moon at a speed of 25,000 miles per hour, it would reach our nearest neighbor in less than ten hours.

What should you expect to find if you could visit the moon? In years past, before the invention of the telescope, astronomers could only imagine what the moon might be like. Today we really know a great deal about it. Galileo, an Italian astronomer, was the first man ever to look at the moon through a telescope. This was in 1610. He noticed the light and dark sections which make the face of the man in the moon. He thought that the large, dark areas were oceans, and so he called them *maria*, which is the Latin word for seas. But Galileo's seas are actually great flat plains. There is no water on the moon.

You certainly would not expect to find plants and animals where there is no water. The moon, like little Mercury, has no atmosphere around it. Because of this lack of air there is no water on the moon, no clouds, and no wind. It would never storm there, but would always be clear.

Scientists know now that much of the moon's surface is not flat and smooth, but rough and rugged. High mountains and deep valleys can be seen and photographed through a telescope. One deep canyon in the lunar Alps, called the Alpine Valley, is about 5 miles wide and 75 miles long. On the side of the moon which is always turned toward the earth, astronomers have counted more than ten thousand craters. Some of them are too small to be seen through a telescope; others are as much as 150 miles in diameter.

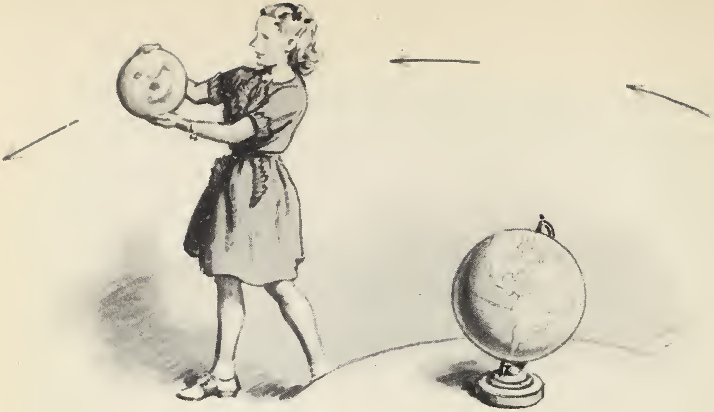


Meteors probably fall upon the moon as they do upon the earth. Since there is no air on the moon to slow down their speed, these masses of metal and stone from outer space would hit the moon very hard. The craters may have been formed in this way or by the action of volcanoes.

The picture on page 62 shows some of the moon's craters and seas. Pictures like this are made with cameras attached to telescopes. All the pictures ever made show parts of this same side of the moon and never of the other side. Why is this? The moon rotates, or spins around like a top, in the same time that it takes to travel around the earth. Because of this it always turns the same side toward us. Do you understand these two motions that go on at the same time?

One of the most interesting things about the moon is the way it changes in appearance from night to night. You must have noticed it growing from a thin sliver of light to a beautiful crescent, then to a lopsided circle, and finally to the gorgeous round full moon like a silver ball. After full moon the moon seems to grow smaller each night for two weeks. Then once more we see it as a crescent. The following experiment may help you to understand the moon's phases, or shapes.

Cover one half of a large ball with a paper on

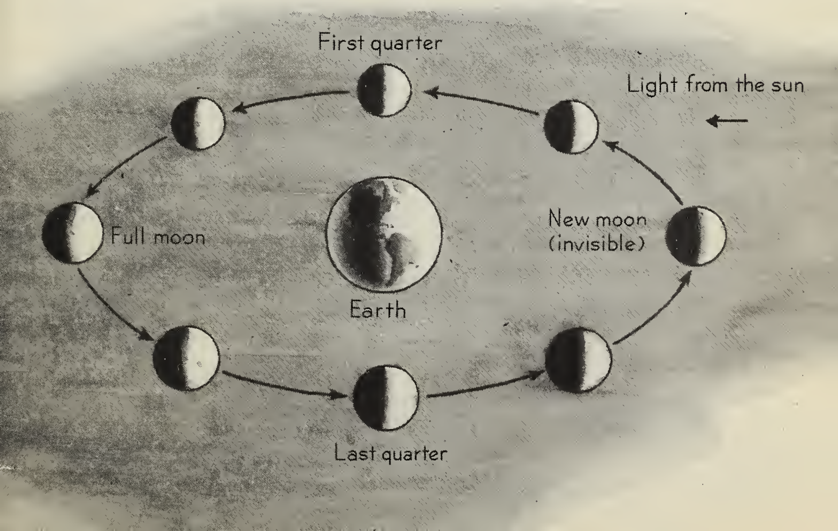


which you have drawn the "man in the moon." Imagine that this is the side of the moon that can be seen from the earth. Carry the ball, or moon, around a globe that represents the earth. Walk in the direction opposite to that in which the hands of a clock move. Be careful to keep the man in the moon facing the globe. The moon will rotate once as it travels around the globe. The real moon behaves in the same way, spinning once as it travels around the earth.

Now darken the room and use an electric light, a flashlight, or a candle for the sun. Stand at the position occupied by the globe. Hold the model of the moon in your hands stretched out high in front of you. Pretend that you are the earth. Stand so that the moon is between the sun and you. When sunlight thus falls on the half of the moon that is turned away from you, you have a new moon, or a dark moon, since the dark side is toward us.

Make a quarter turn to the left and watch for a crescent moon to grow into a quarter moon. One week after new moon, we see a quarter moon, when the moon has moved one fourth of the way around the earth. As you go on turning, more and more of the light half of the moon can be seen from the earth, until at last you see a full moon. Then the moon is on the opposite side of the earth from the sun. After full moon, the lighted part visible from the earth grows smaller and smaller, until once more you see a dark, new moon. Between full moon and new moon, the moon goes through all the same phases in reverse—from full to lopsided (gibbous), to last quarter, to crescent, and finally to new moon again.

On many calendars and in almanacs these chang-



ing phases, or shapes, of the moon are pictured—new moon, first quarter, full moon, last quarter.

There have always been many strange beliefs and superstitions about the moon. One superstition says that when the horns of the crescent moon point upward and the moon itself looks like a cup, the weather will be dry and no rain will come. People say that the moon in this position will "hold water." But others say just the reverse—that because the moon will hold water when it looks like this, it is a wet moon. And when the moon is tilted so that water might spill out, some say it is a wet moon, while others say that the moon itself under such conditions would be dry, and that therefore we should have dry weather. You can take your choice. None of these superstitions contains a bit of truth.

Keep a record of the weather at the time of crescent moon and see whether your record proves anything. Don't check just once or twice; keep your record throughout the school year.

Because of the science work you are having in school you will learn not to believe in superstitions. Look for yourself; check the statements that other people make. Do you or don't you believe that the following statements are superstitions?

1. Change of the moon, change of weather.
2. Fish bite best at full moon.

3. Set your hens and brand your cattle in the dark of the moon; but shear your sheep and prune your trees in the light of the moon.

4. When the new moon appears in the west, be sure to see it first over the right shoulder if you want it to bring you good luck.

The moon does not tell us when it will rain or when it will be cold. It has no effect on the weather of the earth at all. It is just a neighbor of ours, moving around us, obeying the same forces that control the earth and the rest of the solar system.

There are many facts about the moon which scientists know and can prove. Since a day on the moon lasts two weeks, the moon's surface becomes very hot in the middle of the day, much hotter than it would become if the moon had an atmosphere surrounding it. To us on the earth it is very hot when the thermometer reads 90 degrees Fahrenheit. Yet at noon on the moon the temperature is above 200 degrees.

You could have lots of fun jumping and playing on the moon. Since it is less massive than the earth, you would weigh less, because the gravitational pull would not be so great. You would weigh only one sixth as much as you do on the earth. You could jump six times as high and throw a baseball six times as far. Climbing mountains, and there are

many very high ones on the moon, would be fun, too. And you might be surprised to look out into the sky and see the earth shining like an enormous moon, for it too reflects sunlight and changes phase.

Nights on this dead world are just as long as the days. Two weeks after noon on the moon it is midnight. Since there is no blanket of air to retain the heat of day, the temperature drops to about 260 degrees below zero. Our freezing weather on the

earth is 32 degrees above zero. Do you think that you would want to stay long on the moon?

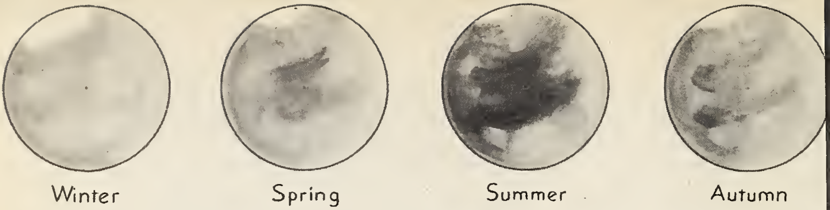
Mars, the Red Planet. Mars has a diameter a little more than half as long as the diameter of the earth; and this planet weighs much less than the earth. You would weigh about one third as much on Mars as you weigh now because the gravitational pull there is less.

Mars spins around at such a speed that a Martian day is only a few minutes longer than our day—37 minutes and 22.58 seconds longer. Since Mars is farther from the sun than the earth is, a Martian year is almost twice as long as ours. A Martian year has 687 days. Mars has seasons much like those on the earth, but each season lasts nearly twice as long.

Since Mars is farther from the sun than the earth, should you expect it to be as warm there? At noon in the summertime a thermometer on Mars might register as much as 86 degrees Fahrenheit. Often in the summer your thermometer goes higher than that.

Although the daytime temperature on Mars may be warm enough for comfort, the nights are very cold. Astronomers believe that at twilight the temperature is about 10 degrees and at midnight far below zero.

Besides being cold at night, you would have a



great deal of difficulty in breathing on Mars. There is only about one thousandth as much oxygen in the air there as in the air we breathe. This might be enough for some forms of life, but not for you and me. Animal life and plant life would need water, too. Most astronomers believe there is very little water on Mars.

If you were out in space looking back at the planet Earth, you would see white areas around the poles of the earth, wouldn't you? And you know these white spots are composed of snow and ice, the polar caps. Through the telescope the astronomer sees polar caps, or white spots, at the poles on Mars. In the summer these caps grow smaller and in the winter larger. On the Earth the polar caps grow smaller when the warmer weather of summer melts the ice and snow. Perhaps that is what happens on Mars too, although we cannot be sure. If the polar caps are snow and ice, as they appear to be, then there is water on Mars.

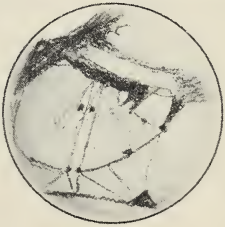
Many years ago astronomers first noticed through their telescopes broad areas on Mars which they called seas. Now we know that they are dry regions and not oceans of water. The reddish regions are probably deserts much like our own. Astronomers have been greatly interested in the strange straight lines which crisscross the surface of Mars. An Italian astronomer called these canals, but by this he meant channels, not man-made canals.

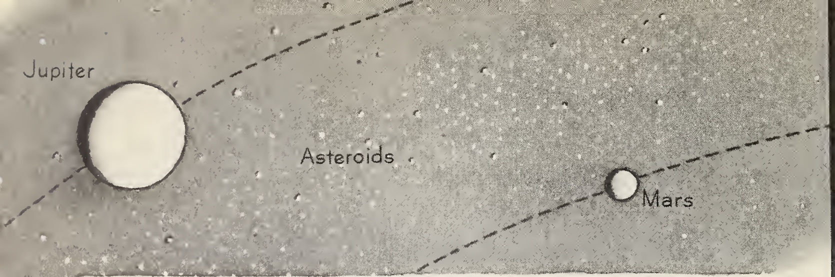
Astronomers who believed that the canals on Mars were waterways thought they were made by intelligent beings like ourselves. They believed the purpose of these canals was to carry water from the melting polar caps to irrigate the desert regions. But today astronomers doubt that people like ourselves live on Mars and that the canals are waterways.

From photographs which have been taken of Mars through big telescopes, astronomers have drawn maps like the one in the picture below. The markings on the map are clearer than those in the photographs.

Much of the surface of Mars changes color with the change of seasons. When summer comes on Mars, a large part of the surface of this planet changes from brown to green. Astronomers believe that this means that new green plants are beginning to grow.

The deserts of Mars are red because much of the oxygen in the air of Mars has combined with the iron in the rocks to form rust.





This probably explains why there is so little oxygen left in the air on this planet.

Is there life on Mars? If there is, what is it like? The answers to these questions are still a mystery. Astronomers feel sure that plants grow on Mars but are very uncertain as to whether any kind of living creatures could exist there. Perhaps with larger telescopes we shall learn the answers.

Asteroids, the Little Planets. You now know something about four of the major planets—Mercury, Venus, Earth, and Mars. Traveling around the sun in their paths, or orbits, in the wide space between Mars and Jupiter, are many thousands of tiny little planets called asteroids, or minor planets.

The diameter of the largest asteroid is about 500 miles. If you could visit these tiny planets, you could easily walk all the way around some of the smaller ones, for they are only a mile or so in diameter. These little planets are too small to hold an atmosphere, for the pull of gravity of such a small planet is very slight. You would feel very light on your feet, and if you jumped high off the ground, the gravitational pull might not be strong enough to pull you back again to the surface of the asteroid.

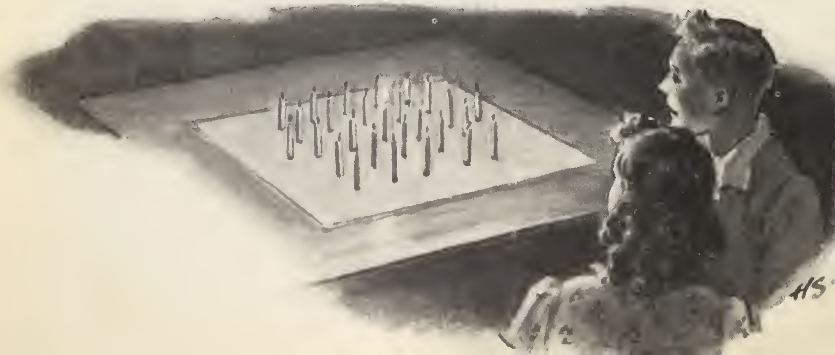
Although only about one thousand five hundred of them have been named and studied, it is believed that there are between forty and fifty thousand asteroids.

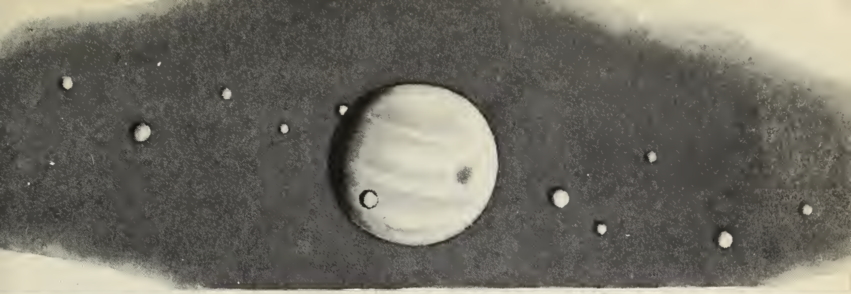
Jupiter, the Largest Planet. Beyond the ring of asteroids lies Jupiter, giant planet of the skies. Jupiter is larger than all the other eight planets together, and more than a thousand times larger than the earth. You must have seen Jupiter many times, for Venus is the only planet that is brighter.

Jupiter's day lasts nearly ten hours, for the big planet rotates at a speed of thousands of miles in one hour. Although a day on Jupiter is short, a year there is equal to nearly twelve of our years. Since it is so far from the sun, and therefore has a longer path to travel, and since the more distant planets move more slowly, Jupiter's year would naturally be much longer. It would seem strange, would it not, to live on a planet with such short days and such long years?

But what about other conditions on Jupiter? Even if we became used to the quick, whirling days and the long, slow years, could we stand certain other conditions on this mighty world? You will recall that light from the sun reaches the earth in about eight minutes. But light from the sun travels almost forty-five minutes before it reaches Jupiter. This light from the sun spreads out and grows dimmer as it travels away from "Old Sol." Just as we set a movie machine close to the screen to get a bright picture and move the machine farther back to get a less bright picture, so the light of the sun as it travels out into space spreads farther and farther and gets dimmer and dimmer. Jupiter, then, would be much darker than the earth. Should you like to see how much darker?

Fasten twenty-seven birthday candles so that they stand up on a piece of glass. Light the candles and darken the room. Pretend that this is the amount of light that reaches the earth from the sun. After a few seconds, blow out twenty-six of the candles. You can think of the light of one candle as the amount of light received by Jupiter from the sun in comparison with the light of twenty-seven candles representing the light received by the earth.





Should you like such a dim world? Of course, since Jupiter is so much farther away from the sun and receives only one twenty-seventh as much sunlight, it must be much colder there too—about 216 degrees below zero. No, you could not live on Jupiter!

We know that the material of which Jupiter is made is much lighter than that of planets nearer the sun. We know also that Jupiter's atmosphere is very deep. This, of course, makes the planet seem larger. In this atmosphere are ammonia and methane, which are gases much like the gas in your kitchen stove. Both gases would be poisonous to living things as we know them. We can be sure that there is no life as we know it on Jupiter.

Jupiter has a large family of eleven moons; so there is always plenty of moonlight on the giant planet. Sometimes there are as many as five moons in its sky at the same time, and at different phases. The four largest moons were discovered by Galileo in 1610 and are therefore called the Galilean moons.

Saturn, a Planet with Beautiful Rings. Saturn is thought by many people to be the most beautiful of all the planets when viewed through the telescope. It is the only planet with rings and for this reason stands out among its fellows. Saturn has nine moons, eight of which travel in one direction. The ninth, which is called Phoebe, moves backward, or in the opposite direction to the other eight.

But Saturn is most famous for its three rings, which are made up of billions and billions of tiny little moonlets, some of them no larger than grains of sand. These tiny bodies shine by reflected sunlight, just as the planets and moons do. Half of the light that the planet sends out is reflected by its rings. When you see Saturn through a telescope the rings look like the straight brim of a man's straw hat. The rings are about ten miles thick and many thousands of miles across. Except for its rings Saturn is much like Jupiter, with short days, a long year (almost thirty times longer than ours), and a poisonous atmosphere.

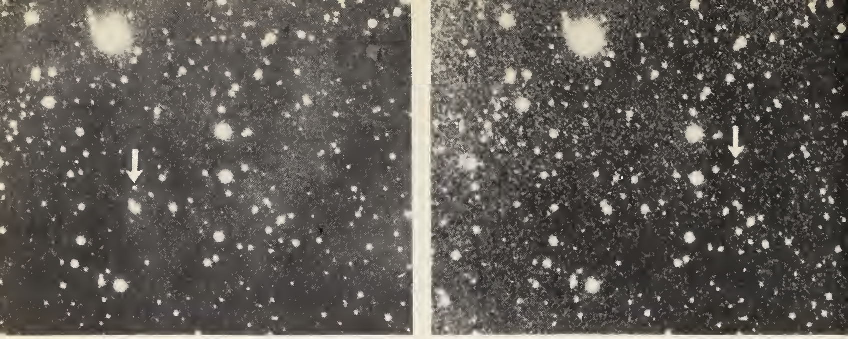
The temperature on Saturn is much colder than that on Jupiter. Under such circumstances no life as we know it could exist there.

Uranus and Neptune, the Large Twin Planets. The twin planets Uranus and Neptune seem small when we compare them with Jupiter and Saturn; but when compared with the other planets, they are huge. Uranus is 32,000 miles in diameter, and Neptune is 31,000 miles. Each then has a diameter much greater than that of the earth. As you know the earth's diameter is more than 7000 miles.

The day on Uranus is nearly eleven hours long, and on Neptune nearly sixteen. Uranus is nineteen times as far from the sun as our world is, and takes eighty-four of our years to complete one trip around the sun. Neptune must travel even farther. One year on Neptune lasts as long as one hundred sixty-five earth years.

The discovery of Neptune is one of the most interesting stories about the planets. Several astronomers had seen it before its discovery was announced, but had not recognized it. What other sciences besides astronomy have helped men to discover the planets?

People like ourselves could never live on either Uranus or Neptune. Their atmospheres, like those of Jupiter and Saturn, are very deep, and are composed of poisonous gases. Both Uranus and Neptune are cold and dark, for the sunlight that reaches them is weak and faint.



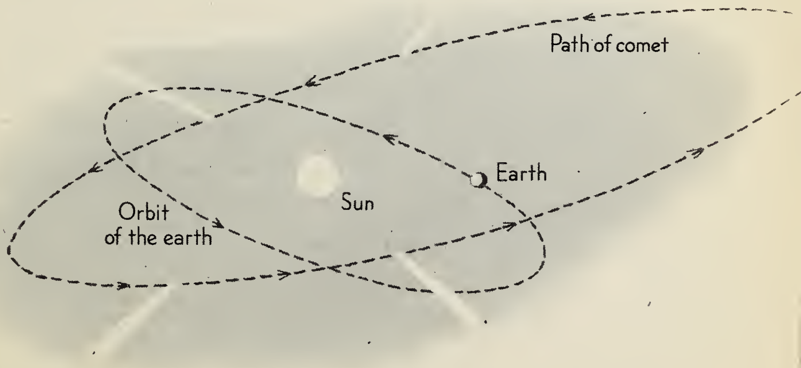
Lowell Observatory

Pluto, the Latest Addition to the Family. Neptune was discovered in 1846, but thereafter for nearly one hundred years no new planets were found. When your mother and father went to school, the schoolbooks said that there were only eight planets traveling around the sun. But astronomers had for a long time noticed something strange in the way Neptune moved in its orbit. And they began to believe that somewhere out beyond Neptune there must be another planet whose gravitational force was pulling Neptune a little bit out of its path. And so they began to search for another planet even farther from the sun than Neptune. And then, on their photographic plates like the picture shown above, one day in 1930 they found a tiny speck. They wondered if this could be the planet for which they were searching. Remembering that the planets are wanderers and move against the background of the stars, they compared two photographs of this little object taken at different times. They found that it had changed its position. And in this way they knew they had found their planet.

The new wanderer was called Pluto, after the ancient god of the cold, dark underworld. This seemed appropriate, for Pluto must be the coldest and darkest of the known planets, since it is between three and four billion miles away from the sun. The first two letters of the name also stand for the initials of the great astronomer Percival Lowell, who long ago foretold the existence of this planet.

Astronomers do not know much about Pluto. It is so far from the sun that its year is equal to about two hundred forty-eight earth years. Pluto is about three-fourths the diameter of the earth.

Comets. Comets also belong to the sun's family. These interesting bodies, with their fan-shaped tails, travel in long curving paths around the sun. They travel around the sun somewhat as the planets do,



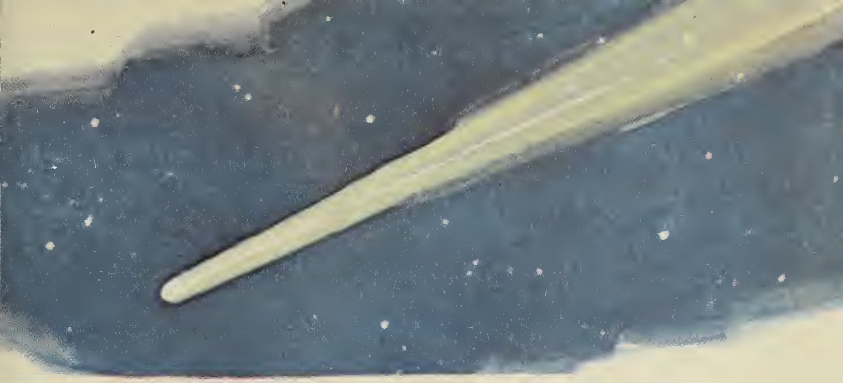
although their paths are much longer and not so nearly circular as the paths of the planets.

Comets have both heads and tails. The head is made up of separate masses of solid material much like that of meteors. The earth was apparently hit by the head of a comet several hundred thousand years ago. Out in the desert in Arizona there is a great hole in the ground nearly a mile across that many astronomers believe resulted long ago from a collision with a comet.

A comet's tail is very thin and is a better vacuum than anything we can produce on earth. We can see through the tail of a comet to the stars far beyond. No comet develops a tail until it is close to the sun, and some not even then. Astronomers think that probably the pressure or force of sunlight causes the tail to form. They know that light exerts pressure, and they think that the pressure of sunlight when the comet is near the sun forces gas and dust back from the head to form the tail. For this reason the tail always points away from the sun.

When comets are in the neighborhood of the sun they are very bright. Their light is partly reflected sunlight and partly their own light.

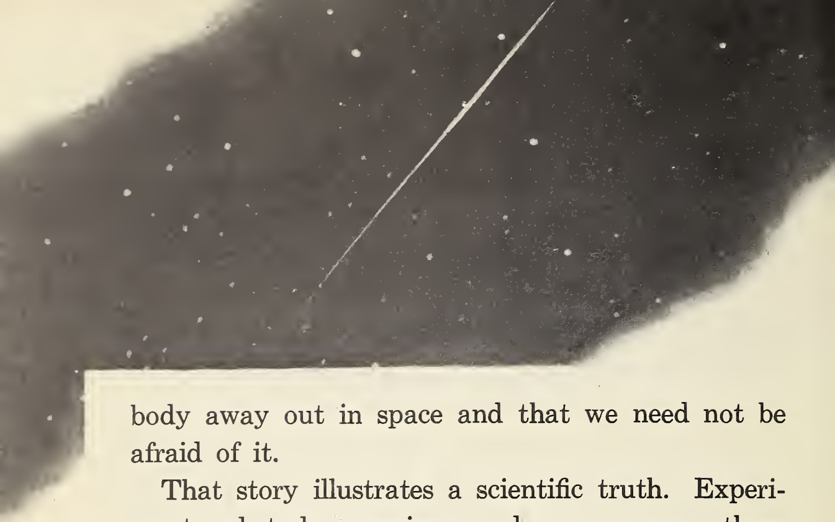
Some comets do not have tails, and some have more than one tail. One of the most famous comets boasted six fan-shaped tails.



The earth has passed through the tails of comets many times and has suffered no damage. This happened in 1910. How could the earth be harmed when a comet's tail, after all, is only a vacuum?

Sometimes comets are so bright that they can be seen in the daytime. When this happens, there are always many people who are sure that the end of the world is coming; for the ignorant person is likely to be afraid of what he does not understand. In years gone by it was thought that comets foretold war, famine, flood, plague, almost any kind of trouble—even the death of kings. This kind of thinking is like the false beliefs and superstitions about the moon, which are common even today.

Many people believed that the great comet of 1577 foretold the end of the world. But a great Danish astronomer, Tycho Brahe, studied it carefully and proved that it was just another heavenly



body away out in space and that we need not be afraid of it.

That story illustrates a scientific truth. Experiment and study, experience and common sense, these can help us to escape from false fears and terrors. If someone should tell you, for example, that comets cause great floods, you would want to read all you could on the subject of floods and their causes. You would ask people who have studied floods and comets what they know about this statement. If careful study led you to believe that there is no connection between floods and comets, then that is probably a sound conclusion to draw.

Here are some interesting statements that seem to relate the heavenly bodies to happenings on the earth. Do you think they are true? Why? Why not?

1. The comet of 1618 foretold the eruption of Mount Vesuvius.

2. When Saturn, Jupiter, and Mars are close together in the sky, a great disaster will occur.

3. When a star (meteor) falls, someone dies.

4. If you make a wish when you see a shooting star, your wish will come true.

Meteors. Have you ever wished on a streak of light in the sky—a shooting star? Shooting stars do not make wishes come true. Nor are they real stars.

Shooting stars are meteors, fragments of stony or metallic material which, like the planets, have been traveling through space. Many of them travel around the sun. When these bits of matter, some of them very small and some of them weighing many tons, come rushing down through the atmosphere of the earth, they rub against the air. This rubbing is called friction, and it makes the meteor glow with light and heat. (You know how the Indians made fire by rubbing two sticks together.) Most meteors

burn up before they reach the earth, but some land on the earth, and then we call them meteorites.

Meteors travel through the sky very rapidly—from thirty to forty miles a second. We never see them until they enter the earth's atmosphere. Out beyond the atmosphere there is nothing for them to rub against and make them glow with light. At certain times in the year we see showers of meteors, which are probably caused by the breaking-up of the heads of comets.

It is fortunate for us that there is a blanket of air, an atmosphere, surrounding the earth, for it protects us from the rain of meteors. Although meteorites have been seen to fall and have sometimes done great damage, we have no record of the death of any human being caused in this way.

Now and then very large meteorites are found. The great Ahnighito (which the Eskimos called The Tent) weighs about 36½ tons, and is to be seen in the hall of the Hayden Planetarium in New York. A larger meteorite, weighing about 60 tons, is still in the ground where it fell in South Africa.

Some people believe that the great crater in the ground in Arizona was not caused by a comet, but by an enormous meteorite. It would be very hard to know now which is true, because the head of a comet is made up of meteors.

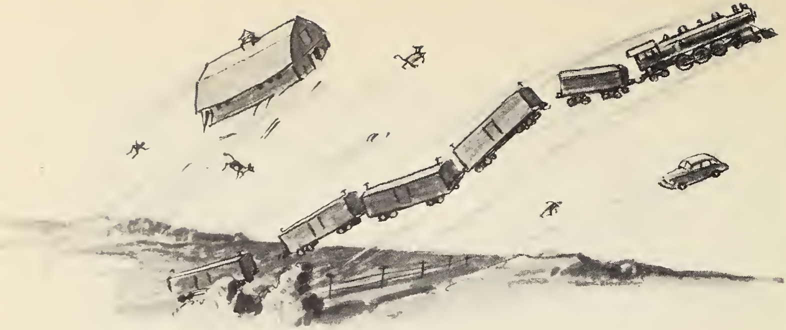
We have now learned much about our neighbors in space. Planets travel around the sun, and moons travel around many of the planets. Comets visit us, some at short intervals, and others once in a long while. Showers of meteors rain down through the atmosphere every so often. Thanks to the never-ending studies of astronomers, these facts and many others are understood by educated men today. As each new truth is learned, another area of ignorance and superstition disappears.

The lessons we have learned about our own solar system can help us with other problems. Seek the facts! Every effect has a cause if you only know where to look for it. When you find the facts you need, you can answer the questions that puzzle you. When you do this, you become a more useful member of the community in which you live.

MORE THINGS TO THINK ABOUT

1. Imagine a trip to the moon in a newly invented rocket ship. Tell about the conditions on the moon for which you would have to prepare if you expected to return to tell about your trip.

2. What would you expect to find if you could visit each one of the planets?



3. Compare the length of the day on all the planets.

4. Which planets have moons? Look up those about which you do not know.

5. Find out what the ancients thought of meteors, of comets, and of the other heavenly bodies, including the sun itself.

6. Tell, so far as you can, what would happen if the force of gravity suddenly did not work. What would happen to the stars? to everything on earth?

7. Use the table on page 52 to find out how far the planets are from the sun. Compare this distance with the diameters of the planets, given on page 51. Do the diameters of the planets seem large when compared with the distances between them?

8. The sun is 93,000,000 miles from the earth, and the moon is 240,000 miles away. How many times farther away is the sun than the moon?

9. Suppose the moon were a star. What difference would that have made to the earth and to the people upon it?

MORE THINGS TO DO

1. Play What's My Name? in class. In this game the leader thinks of the name of a heavenly body and tells the class one fact about it. If anyone can guess the name from this fact, the guesser gains ten points. If no one guesses the name, a second fact is told. Eight points are awarded to the one who guesses the correct answer from this clue. Each time no one guesses the answer, another fact must be added and two points less given. The leader's score is the difference between ten and the points finally won by the one who guesses correctly.

2. Try making a model of the solar system on the playground. If you imagine the sun far off the playground, can you make the rest of the heavenly bodies to scale? Can you mark the distances properly? Fence in your model and give a talk to the rest of the school.

3. Try to find planets in the sky. Your newspaper may tell you when and where to look for them.

4. Try to disprove the next superstition you hear by stating facts.

The Ocean Is a Great Storehouse

Oceans All Around Us

In the last chapter we learned that the planet on which we live is surrounded by an ocean of air which we look through when we see our neighbors the stars. Now we shall learn about the great ocean of water that is on our planet, the earth. Almost three fourths of the surface of our planet is covered with water. Most of this water is found in five great oceans, or parts of the one great ocean.

Men traveled over these oceans for many, many centuries without knowing very much about them or about the life that is in them. They had many old and interesting stories, and songs too, about these seas before they knew anything about their depths.

Instruments invented within the last fifty years have made it possible for us to learn new things about these great bodies of water. In fact most of our scientific knowledge about the oceans and their depths is recent.

Exploring the Ocean Floor

Let us learn about the oceans by imagining a basketball is the planet on which we live. If you take the basketball and dip it into a pail of water, some of the water will stay on parts of the ball after you take it out. Let us suppose that the basketball is the earth and the wet parts are the oceans, lakes, rivers, and other bodies of water that cover three fourths of our planet. The water is not very deep, is it? The water on the earth is very shallow, too, if we compare its depth with the diameter of the earth.

Measuring the Ocean Depths. As we stand on land and look out over the ocean, we see only the surface of it. Below this surface, ever moving and changing, the water may extend downward many miles. Several methods have been used to find out how deep the ocean is. Probably the oldest method is to drop over the side of a ship a strong wire or rope with a heavy weight on the end to carry it down to the floor of the ocean. The length of the wire or rope let down into the water, of course, indicates how deep the ocean is at that point.

Today the depth of the ocean is often measured with instruments that send electrical impulses to the bottom of the ocean. When an impulse strikes the floor of the ocean, it bounces back to the boat from which it was sent. Since scientists know how fast the impulse travels, they can thus find the distance to the bottom of the ocean. A depth of more than 6 miles has been reached in this modern way. By measuring depths at a number of places in the ocean, men have been able to make maps of its floor that show its various depths.

Certain men have spent most of their lives in studying the ocean, and some countries have spent large sums of money to fit vessels for gathering information about it.

The British ship *Challenger* was one of the first to go on a voyage to gather information about the floor of the ocean. In 1872, while pioneers in the United States were still settling the western part of the

country, this ship began its pioneer work. For three and a half years the British government sent the *Challenger* back and forth across the oceans of the world.

The pioneers on this ship used the old method of measuring the depths with ropes and weights. They measured other things too. They measured the temperature of the water all the way down. They got a sample of the bed of the ocean whenever they measured. Records of the weather were so carefully kept that we know from them what the weather was like at any time during the three-year adventure.

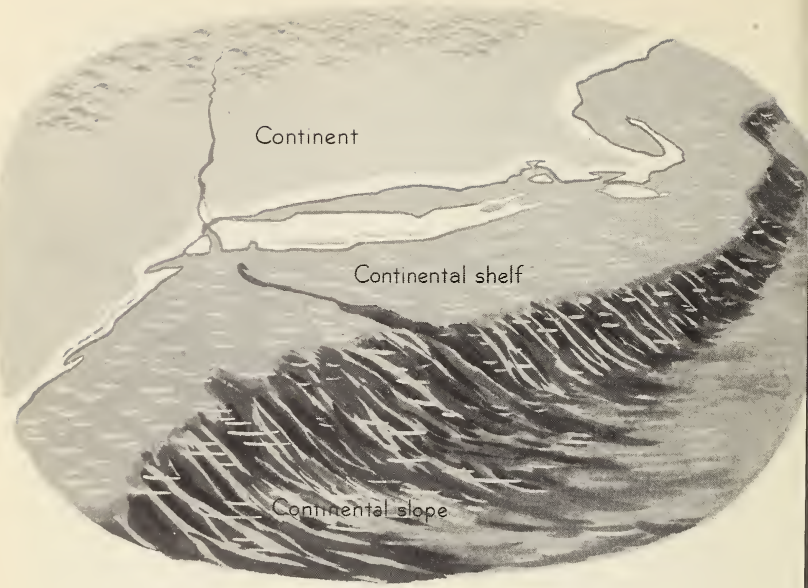
These pioneer scientists recorded many other facts. If you were told that they did not know how these facts would be used, you might not believe it. Yet this was true of the pioneers on the *Challenger*.

Although these early scientists could not know what values might come from all their records, they had the attitude of scientists toward facts. They believed that facts are important and that it they recorded them carefully and accurately they would be useful at a later time.

The collecting of new facts has always been considered unnecessary by those who do not understand. Yet many times such facts have later proved to be of great value to scientists. The more facts you have about anything, the nearer you will come to knowing the truth about it. The more facts men have collected about the oceans, the more useful have these large bodies of water been to men. Scientific studies of the ocean beds have helped men to find oil fields there.

Because the operators of modern sound-detectors knew from these earlier pioneer records the type of ocean bottom they measured, they could obtain truer results with their instruments. When they knew how warm or how cold or how salty the water was at a certain point, they could tell more exactly what their sound-detectors reported, because sound travels at a different speed in different temperatures and in different amounts of saltiness. The weather records made on the *Challenger* and other ships that explored the oceans have also been of great help in modern weather predictions.

Hills and Valleys under the Ocean. If you have seen the ocean, you know that on some days its surface looks smooth. On other days waves make it



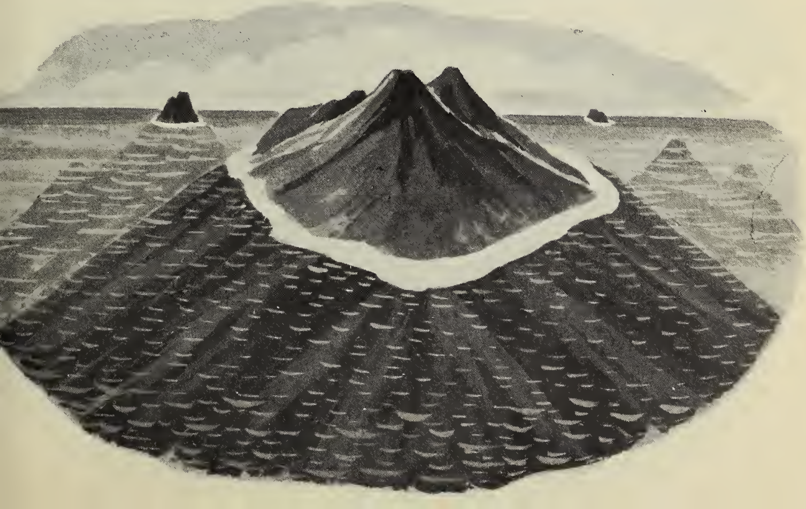
rough and uneven. But if you compare the surface of the land you have seen with the surface of the ocean, the ocean will seem fairly flat.

But suppose you could travel across the floor of an ocean that has had all water drained out of it. As you left the shore, you would travel gradually downhill over a sloping plain, called the continental shelf. At certain places the shelf slopes downhill 10 miles, and at others it drops gently for a distance of 150 miles. Think how long such an incline would seem if it were on the land where you live. All continents are bordered with a continental shelf.

At the outer edge of this shelf there is a steep drop, called the continental slope. If you traveled out from the shores of the New England states and New Jersey about 165 miles, you would see this drop following the shape of the shore line. It is a mile deep in some places.

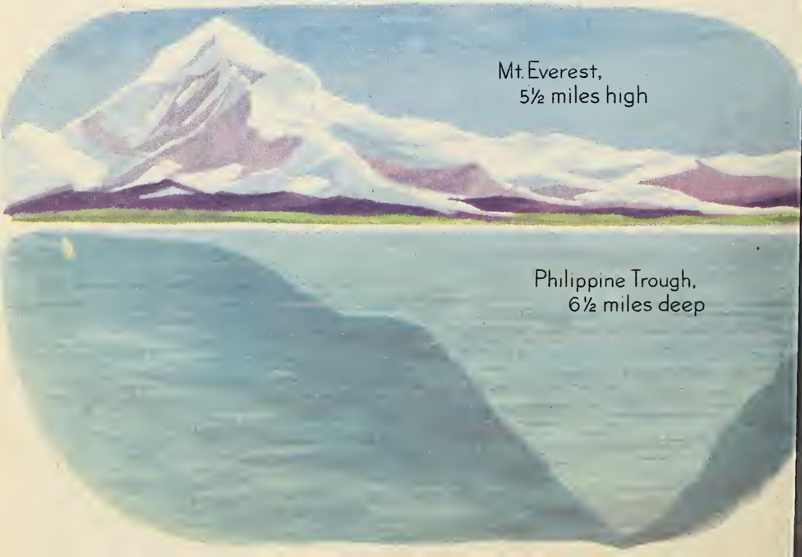
The continental shelf along the Pacific coast of North America is not wide. Along part of the coast line between California and Alaska the continental slope is about 15 miles from the shore.

After you had left the end of the continental slope, you would journey along the even floor of the ocean for miles and miles on a plain that would make the Sahara Desert seem small in comparison. Here and there mountains and canyons would be found, which change the flatness of the ocean



floor. Jagged valleys and great volcanic mountains are also found at the bottom of the ocean. Sometimes these volcanic mountains rise high enough out of the water to form islands. The Hawaiian Islands are really the tops of mountains that stand in water. The peaks of other mountains form the islands off Alaska and the islands around Cuba. But not all mountains in the oceans rise above the surface of the water. There are whole ranges of mountains entirely under water. Also lava from some of these undersea volcanoes has piled up so high that it has formed islands above the water.

In contrast to the high mountains there are deep, deep valleys in the floor of the ocean. One of the deepest of these valleys is east of the Philippine Islands. Scientific instruments show that the deep-



est part of this valley is from six to seven miles below the surface of the ocean. If you have ever hiked a distance of six miles, you will have some idea how far down under the ocean these valleys are.

The highest mountain on land is Mount Everest in Asia, which is about five and one-half miles high, while the ocean valley near the Philippines measures at least six and one-half miles downward.

The Ocean Floor. Man has learned not only to measure the depths of the ocean with instruments but also to get samples of the bottom of the ocean by scraping it with dredges. From these samples we learn what the floor of the ocean is like.

Fine sand and mud are found on the bottom of the ocean as far out as 200 miles from the coast; but fine sand makes up most of the floor of the continental shelf. Some of it is green, some is blue, and some is red.

Beyond the continental shelf a different kind of material is found at the bottom of the sea. Over most of this deeper part of the ocean bed is a slimy ooze, different from anything found on land. Ooze is made of the skeletons of millions of tiny animals, and of some larger ones, dead plants, volcanic ash and lava, the dust of meteors, and sand and pebbles that have been carried out to sea by floating ice.

Pieces of wrecked ships, and things that have been lost at sea and fallen to the bottom and rotted, have also become part of the ooze. But the ocean floor is composed chiefly of the skeletons of tiny things that once lived in the water above.

Sea plants and sea animals are interesting to study. Most of them are so small that they can be seen only with a microscope. After these little animals die, their shells or skeletons sink to the ocean bed, just as grains of sand would drop to the bottom of a glass of water. More than one hundred thousand tiny shells might be found in one square inch of ooze. A half-inch layer of this ooze might have taken as long as a thousand years to form.

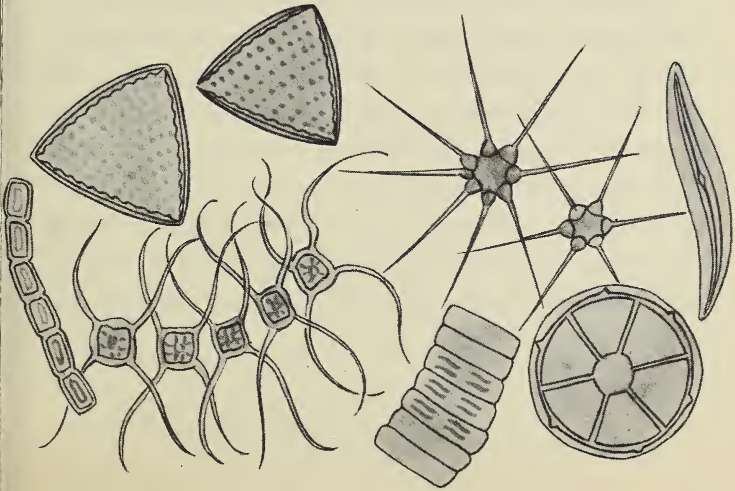
Some people say that objects that fall into the ocean "find their level." They believe that the weight of an object carries it down only a certain distance. This statement may seem true to you, but you can actually prove whether or not it is.

Fill a large glass jar or a deep glass cylinder full of water. Drop into it as many different objects as you choose. Suppose you drop a dime, a pebble, a marble, and a dried pea into it. What becomes of these objects? If they do not go all the way to the bottom, what becomes of them? Is the answer to your experiment that objects dropped in the ocean "find their level"?

Plants in the Sea

Diatoms. Sea plants do not always have their roots in the ocean floor. Some plants may be attached to objects in the water, and others grow near its surface. Tiny plants like those in the picture on this page float near the surface, where they can get sunlight. These are the diatoms whose skeletons help to make up the ooze of the huge ocean floor. In this picture the diatoms are at least two hundred times larger than their true size.

These tiny plants are very simple living things. They use sunlight to help them to make food for their little bodies. Diatoms are enclosed in walls, with an overlapping edge, also made from chemicals in the sea. Their shell-like coverings fit together like the halves of a small round pillbox and are as beautiful as anything in nature.



Many other tiny plants besides diatoms live in the ocean. More than two hundred fifty thousand plants have been counted in one quart of water taken from the surface of the ocean. But a sample taken from water deeper in the sea contained only two thousand plants of about the same size. Think how small a plant must be if two hundred fifty thousand of them can live in one quart of water.

What possible use do these tiny living things have for us? Their greatest use does not come to us directly. They are the food of fishes and whales which are so useful to man. In fact the Greenland whale, a creature forty or more feet long, lives almost entirely on these sea plants. Codfish and tuna also use diatoms for part of their food. When you next eat codfish remember the millions of little diatoms that helped to make this good food for you.

Seaweed. One of the larger sea plants which is valuable to man is the seaweed. If you have climbed among the rocks at the seashore when the tide was low you have perhaps found them slippery with seaweed. Bubbles found in some kinds of seaweed float the weed on the surface of the water, where it gets enough sunlight to live. These plants, which are often several hundred feet long, make food from the chemicals in the water just as the diatoms do.

Seaweed plants weighing as much as 100 tons have been found in tropical waters. Kelp is a kind of seaweed which is sometimes as much as 300 feet long. After drying these long pieces, men have used them for fishing lines.

Seaweed is also used in another way. For a long time chemicals have been taken from seaweed to use as fertilizer. Today men are experimenting with seaweed to see if they can get still more chemicals from these plants. Rows of stones are placed along the seashore to act as traps. The slippery seaweed washes over the stones, that keep it from sliding away. Then machines, almost like the ones that farmers use when cutting hay, are used to cut the seaweed. The weed is piled up on shore to dry and is later used as fertilizer. The gathering and cutting of seaweed is known as seaweed farming.

There is an interesting story about seaweed. When Columbus was sailing toward America in 1492, he found a large tangle of yellow-brown seaweed around his ship. For more than a week he sailed slowly through these slippery plants. His sailors were frightened, because they thought that they were coming to shallow water far from land. Their supplies were almost gone, and they were afraid that they would starve if their ship was stopped by this mass of weed. Some of them even thought that they had come to the end of the earth and could go no farther. Columbus sailed on, however, for almost a month before he reached land.

The tangles of seaweed through which he sailed were in the part of the Atlantic Ocean known as the Sargasso Sea. It is named for the seaweed called sargassum, which floats in the still water.

At one time sailors called this jungle of seaweed "the port of missing ships." They gave it this name because they imagined that ships were wrecked in the tangles of the floating weed. Many amazing tales have described ships as rotting away and sinking below the long trailing plants. Today we know that from 5 to 20 million tons of seaweed float in the Sargasso Sea and that nowhere is it thick enough to hinder the progress of a ship.

How did all this seaweed collect in the Sargasso Sea? Scientists have come to believe that ocean currents moved it there where it stays still, just as the pools in your neighborhood brook remain quiet even though fast currents rush past them.

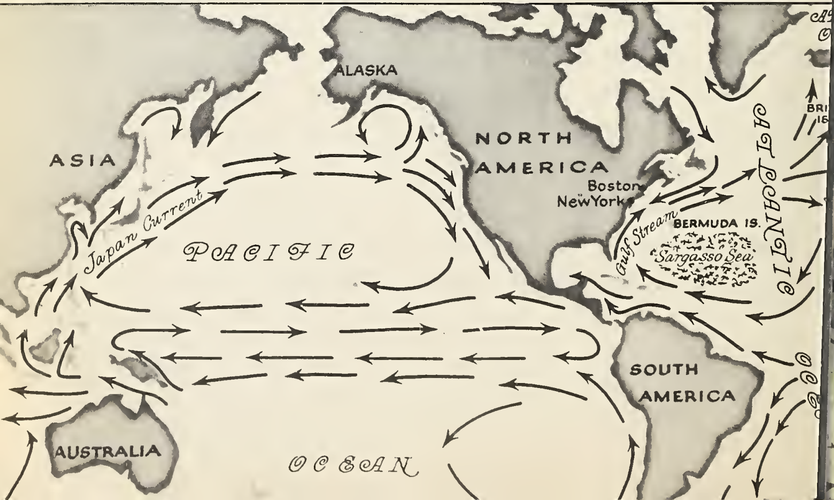
Rivers in the Ocean

In the ocean are currents of water so strong that they look like mighty rivers flowing between banks of calmer waters. The most famous current is called the Gulf Stream. Its warm waters are like a river moving through the ocean. On both sides of this current are colder waters.

Mile after mile this mighty current flows through the Atlantic Ocean north toward the Arctic Ocean. Beginning in the Gulf of Mexico, it swings eastward and finally mixes with the cooler waters of the ocean off the coast of northern Europe.

Scientists have learned that this riverlike current affects man's living conditions, because it changes the climate in certain places. The winds blowing over the Gulf Stream are so warmed by it that the weather in several countries is made milder. England is one of these countries. On its way to Europe, the Gulf Stream flows near the Bermuda Islands. Even though these islands are no farther south than the state of South Carolina, their climate is so mild that flowers bloom there throughout the winter.

The Japanese Current also causes changes in climate. It flows northward along the coast of Asia. From the north of Asia it continues far northeast to the southern shore of Alaska, becoming colder as it flows. One branch of this current turns southward along the western coast of North America. The summer winds that blow over the Japanese Current toward the southern shore of Alaska are mild and moist. This is the reason why the climate of Alaska in summer is warm enough for farming. With your pencil trace the current from right to left on the map by following the arrows.



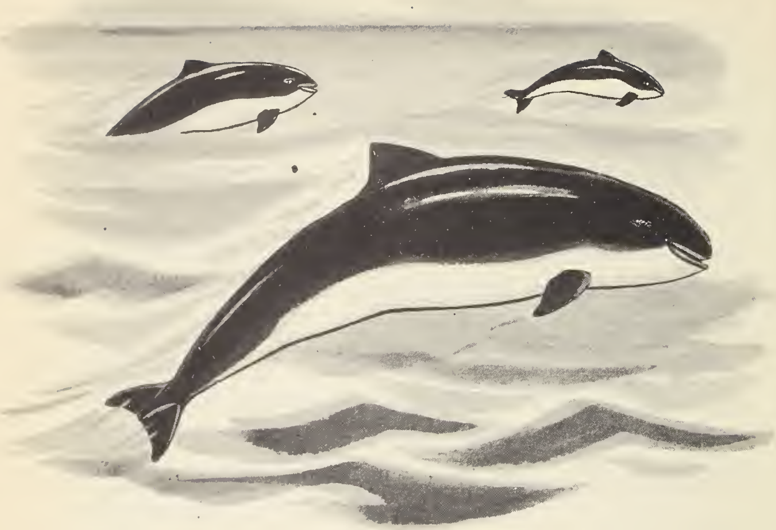
Although the Japanese Current and the Gulf Stream warm the winds, the water would not feel warm if you dipped your hand into it. The Gulf Stream is much warmer, however, than the water on either side of it. Men who sail southwest from Boston or New York can see the warm ocean river, the Gulf Stream. A day or two after leaving port, the dull greenish water changes to a clear, sparkling blue, for the warmer water has a different color.

Those who cross the Atlantic Ocean in wintertime notice that the weather changes after they leave the cold, green water. The farther the ship travels into the bright, blue stream, the warmer the air becomes.

Life in Warm Waters

Life in the Gulf Stream. Many small animals live in the Gulf Stream. Some are the tiny animals whose skeletons drop to the ocean bottom to form the ooze. Some are crabs and fish that match the seaweed in color so well that it is difficult to see them even though they are large. Bits of seaweed float on the surface of the Gulf Stream.

The beautiful colored tropical fish traveling along to the north with the Gulf Stream serve as food for the fish that men eat. Sometimes these tropical



fish are carried by the current far north into the waters off New Jersey.

Other larger animals travel in the Gulf Stream. Porpoises, which are whales about six feet long, are often seen off the eastern coast. Passengers on ships sometimes entertain themselves by watching porpoises leap out of the water. But fishermen do not enjoy seeing them. They know that their catch of salmon and mackerel, which are the favorite foods of porpoises, is likely to disappear or be eaten by them.

One of the largest of the fish caught in the Gulf

Stream is the tuna, which furnishes us with food. Tuna often weigh several hundred pounds. Of the many kinds of animals that live in this warm ocean water, not all can be used by man for food. Chief among the smaller sea animals of this type is the coral.

Corals. Thousands and thousands of corals live together along the shores of the tropics in the warm water. Corals usually live in what have been called coral gardens. If each little animal lived alone it could not easily be seen in the water, for each is less than one-half inch in length.

As the coral grows, a hard limestone coating is formed around its base. Corals have soft arms which can reach out of their hard skeletons when they want to collect food. When a coral animal is in danger, it can shrink back into its hard limestone house, or it can poison its enemies with its stinging

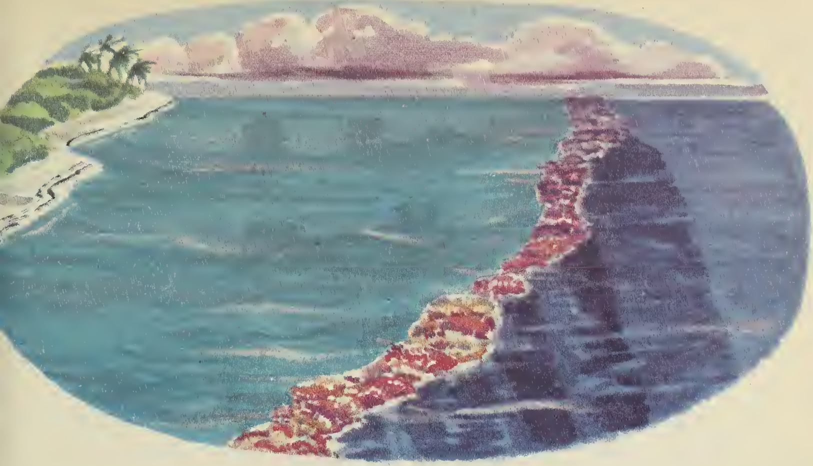
cells. The next time you examine a lump of coral see if you can tell how many of the little animals made one inch of it.

Young corals build on the skeletons of dead ones. One on top of another, corals have built over many centuries castlelike structures of limestone on the bottom of the sea.

Divers who have gone down to the coral gardens in tropical waters have taken pictures of them. Some of their formations look like trees, with trunks several feet thick. Broad, spreading branches form a roof of tangled coral overhead. Think how beautiful such a forest of purple, pink, blue, and orange coral would be.

Some kinds of coral form a crust flat on the sand. Others living together are shaped like a huge brain. Millions of corals may form a leaf shape, and others may group themselves together like petals so that they resemble a rose. Fan-shaped corals with their delicate, feathery branches are very beautiful.

Coral Reefs. In many places coral gardens have grown until they have reached the surface of the water. In warm waters these heaps of dead and living animals form huge piles, known as coral reefs. The limestone skeletons of the coral remain in the water long after the animals die. In this way great piles of coral, thousands of feet high, are formed.



No one knows how many thousands of years it has taken colonies of tiny corals to build these great reefs. The longest reef follows the eastern coast of Australia under water for more than a thousand miles. Since corals are usually less than a half inch in length and since the skeleton is all that remains after the little animal dies, it would be impossible to know how many of them have had a part in forming this one reef.

In Bermuda, coral skeletons, other shells, and sand have been ground by the ocean waves, washed onto the beach, and become cemented together to form coral rock. The surface of the Bermuda Islands is of this rock. Coral blocks sawed from the hilltops are used in building houses there. In the Philippine and other Pacific islands large amounts of coral are ground up and used in making roads. Coral is excellent for this purpose, since water runs off the surface easily. Good roads help the Filipinos to transport their food to market easily. Although the coral does not furnish men with food, it does help the people on tropical islands to live comfortably.

Life in the Oceans of the Far North and Far South

Many animals and plants spend their lives in the cold, dreary seas of the Far North and Far South. Among them are the giants of the animal world, the whales. If a large whale could stand on its tail in front of a building, it would reach as high as the seventh story. Baby whales sometimes weigh more than eight tons.

Whales are not cold-blooded animals as are fish. They are warm, red-blooded animals with great layers of fat under the skin, called blubber, which helps to keep them warm. Whales have lungs for breathing. They must come to the surface of the water for air just as you do when you have been swimming under water, but they can stay under water longer than you can.

When a whale comes to the surface of the water to breathe, warm air comes out of its lungs. Since the air above the ocean is colder than the air breathed out by the whale, the moisture in its breath cools and forms drops. As the whale blows air from its lungs, the water is sent upward in great spouts. "Thar she blows!" the sailors on whaling ships used to cry when they sighted a whale.

Some whales have a strange-looking substance in their mouths, called whalebone. These whalebones are arranged somewhat like the teeth of a comb, and are fastened to the upper jaw. Whales use these whalebones to help them in getting their food. First they gulp water from the ocean. Into their mouths go thousands of small plants and animals along with the water. Then the whales force this water out, but keep the food inside by using the whalebone as a strainer.

Other whales have teeth. Killer whales and porpoises belong to the group of whales that have

teeth. Their huge teeth can bite into small seals and other large whales. These whales are able to fight against very large animals with the energy that comes from eating small animals and very small plants, for example, the diatoms.

Yes, tiny diatoms are taken in by the whale along with millions of other plants and animals. The big creature uses them all to make his huge body. The oil, the blubber, bones, and blood, all can be traced back to the tiny pieces of food that made up the animal's diet.

The blubber is probably the whale's greatest gift to man. Eskimos and other northern folk use it for food. A hundred years or more ago people in this country used oil obtained from this fat in their lamps. One kind of whale oil is now used in the manufacture of face creams.

The Cold Dark Depths of the Ocean

In the deeper parts of the ocean there is less animal life than in the upper surfaces where the whales blow. Explorers who have studied the depths have not found in them as many fish or other forms of life as can be found near the surface. Only a handful of animals was brought up in one net that had been dragged over the ocean floor for several hours.

Sometimes no animals were found in the nets that were lowered into the deep water. Sunlight cannot reach these depths through the water; so the water there is as cold as ice. This is true even of the water near the equator.

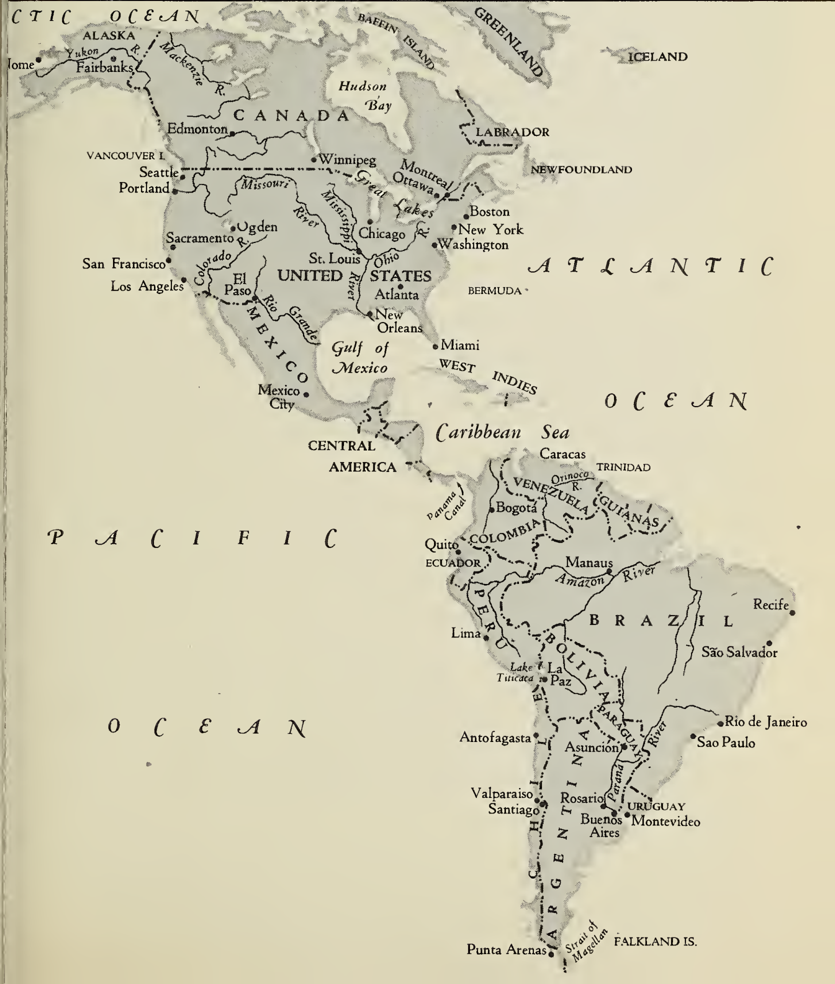
Ooze collected from the floor of the deep sea is so cold that men can hold it in their hands only a short time. In the deep sea there are no summers or winters. It is very cold there the year round.

If you could go into the depths of the ocean, you would not know whether it was August or December, because the weather there does not change. You would also be unable to tell the time of day, because it is always dark below the surface of the water. Even on the clearest of days, at 650 feet below the waves it is not much brighter than pale moonlight. Since the average depth of the ocean is two and one-half miles, most of the ocean is darker than our darkest night on land.

Many deep-sea animals have their own light on them. Certain scientists think that these lights are turned on and off as they are needed. Some of these fish look very much like small ocean liners, with lights along their sides like portholes on a ship. The color, the beauty, and the strength of the light given out by these deep-sea animals have been studied by scientists, but many things about this light still remain a secret.

Deep-sea animals can live only under a layer of heavy water. The pressure inside their bodies is so much greater than the pressure of the air around them that they would burst if they were brought too near the surface.

The food supply of deep-sea fish is not as abundant as is the supply for fish living near the surface of the ocean. The living things that spend their lives in the deep, dark waters depend partly on food that drifts down to them from above. They also eat other animals that live in the depths. On the map below you can find the names of the bodies of water from which Americans get their largest supplies of seafood.



The Ocean a Storehouse of Food

Animals that live near the shore feed on plants as well as on other animals. Almost every living thing in the ocean serves as food for the fish there. Sponges and some kinds of starfish and jellyfish are the only animals that are not used as food by fish.

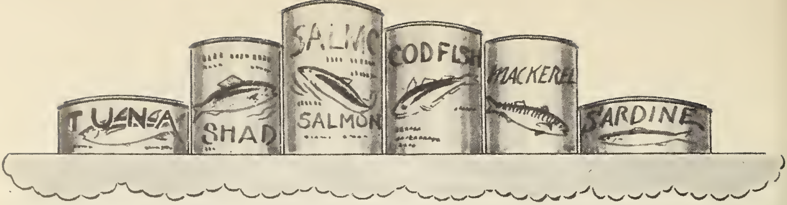
The ocean is a storehouse of food for man as well as for fish. Fishermen bring tons of fish daily from the ocean to our food markets. Herring is one of the most important food fish for men in all parts of the world. Herring are easy to catch, because millions of them travel together in a group called a school. More than ten billion herring are caught each year.

Schools of mackerel are large, too. If all the mackerel in one school could be caught, there would be enough of them to fill thousands of barrels. Each year fishermen catch enough mackerel to fill at least a million barrels.

The tuna is the largest member of the mackerel family. It is sometimes called horse mackerel. In the Mediterranean Sea, in the Gulf of Mexico, and off the coast of California tuna that weigh as much as 500 pounds are often caught. Equally large tuna are caught off the coast of Maine. There is great excitement when fishermen sight a school of tuna. Do you know how tuna is caught?

Codfish travel in schools in the waters of the North Atlantic. Thousands of people earn their living by catching the billions of pounds of cod that are marketed each year. A large part of the codfish catch is salted and dried, so that it can be sent to people who live far inland.

Early peoples preserved fish by smoking and drying them, but today we use newer methods in addition to these. Probably the newest method of preserving fish is to freeze them. When they are not easy to get fresh from the water, we can draw on the supply that has been kept in refrigerators. People living far away from the sea, who need the chemicals



that are in seafood, use canned fish. With so many different ways of preserving fish, people can now appreciate and enjoy the gifts of the ocean more than ever.

WHAT DO YOU THINK?

1. Suppose someone asked you, "What lives in the ocean?" Would your answer be simply, "Fish"? How many other kinds of ocean life can you name?

2. Suppose someone collected a large pail of water from the surface of the ocean far away from land, another from the deep sea, and another from the water near the shore. What would you expect to find in each pail?

3. What helpful uses has man made of scientific studies of the ocean? For example, tell how knowledge of the currents of the ocean may save a flier's life.

4. Do you think it is worth while to gather facts that may not be used immediately? Do you know of any facts that have not yet been put to use by scientists? Look up the story of Cyrus Field and the Atlantic cable. If Field had known more about

the bottom of the ocean, would it have helped him on his long adventure?

5. Look at a map of the world. Find the largest ocean. How does water from the Atlantic Ocean get into the Pacific Ocean? What living things would you expect to find in the Atlantic and Arctic oceans?

6. The ocean is like a great mixing bowl full of water with chemicals dissolved in it. For what new supplies of chemicals do men turn to the sea today? Why is the ocean sometimes referred to as "our last frontier"?

How Animals Survive

Animal Families

The coral whose reefs and gardens we read about in the last chapter has stirred the imagination of many people. Each little animal builds a tiny cup on an older one. In their cuplike homes the corals live and die. It would be impossible to know how many tiny corals, living and dead, have had a part in building the reef off the coast of Australia which is 1100 miles long.

When a living thing succeeds in growing up and producing a new family of living things like itself, it is said to survive. If many animals did not produce a great number of their young, they would have little chance of surviving. Probably the best reason why the coral has survived is that it has produced

large numbers of young. Even though many of them have died, enough have lived to build large reefs and gardens.

To grow to adulthood many animals must overcome great difficulties. First they must be able to get through their babyhood safely. They must find enough food to live on; they must escape their enemies; and they must produce more animals of their kind. Some must learn special ways of taking care of themselves.

Some animals watch over their young until they can take care of themselves, while others leave the young soon after they are born. All animals have at times to struggle for food and to drive off enemies, and each kind is equipped in some special way to help it to survive.

First, let us see how one of the largest of animal families—the oyster family—is able to survive in spite of great dangers.

Starfish eating oyster

The Oyster Family. The famous Old Woman Who Lived in a Shoe had so much trouble she did not know what to do because she tried to care for a large family of children. But her family was small compared with a family of oysters. One oyster may lay more than a hundred million eggs in one year. Scientists tell us that oyster parents do not attempt to take care of their young. The young find food for themselves. It would be impossible for all oysters that are hatched to find food if they were able to survive. Animal enemies in the ocean destroy and eat great numbers of oyster eggs and also many young ones.

After an egg hatches, the young oyster swims about for a day or two and then settles down on a solid object for the rest of its life. Oysters a year old are only about one inch long. They are ready for market when they are from three to five years old.

Because oysters can be used for food and because pearls are sometimes found in them, men have learned to take care of them. Oystermen raise them in protected areas under the water. If they could protect the millions of eggs produced by each female oyster each year, soon there would not be enough room in the ocean for the other animals that live there.

Flounder Families. Most of the other animals that live in the ocean have large families, too. The flounder may lay as many as a million eggs, which fall to the ocean bottom, where they collect in large masses. After a mother flounder has laid her eggs, she swims away and leaves them. Other animals may notice them and make a good meal of them. Because of these enemies, most of a flounder's eggs never become young fish. But enough of the eggs are hatched and grow up to keep many flounders in the oceans.

Guppy Families. You may have raised large families of guppies in an aquarium. You know, then, that guppies have large families that are born alive. Very young guppies are so small that they are difficult to see.

One morning as many as a hundred tiny guppies may be found in an aquarium. Several days later, just the parents and a few young ones may be left.

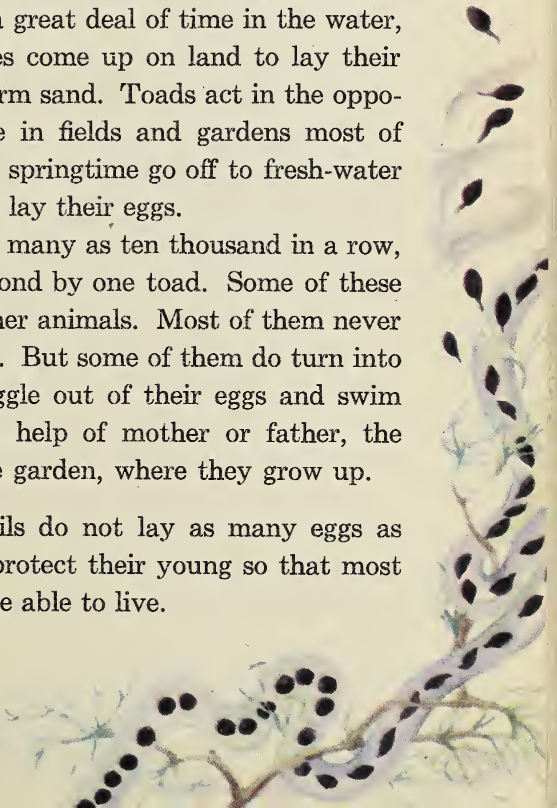
The parents have eaten as many of the young guppies as they could catch.

If you want to raise young guppies, you must save their lives by putting the parents in a separate aquarium as soon as the young are born. You can also protect the baby guppies by putting many stones and plants in your aquarium, so that the young ones can find hiding places under them.

Turtles and Toads. The young of other animal families cannot be watched as easily as guppies can. Most turtles spend a great deal of time in the water, but all female turtles come up on land to lay their many eggs in the warm sand. Toads act in the opposite way. They live in fields and gardens most of the time, but in the springtime go off to fresh-water ponds and creeks to lay their eggs.

Strings of eggs, as many as ten thousand in a row, may be laid in the pond by one toad. Some of these eggs are eaten by other animals. Most of them never produce any new life. But some of them do turn into tadpoles, which wriggle out of their eggs and swim away. Without the help of mother or father, the toads go back to the garden, where they grow up.

Land Snails. Snails do not lay as many eggs as toads do, but they protect their young so that most of the baby snails are able to live.



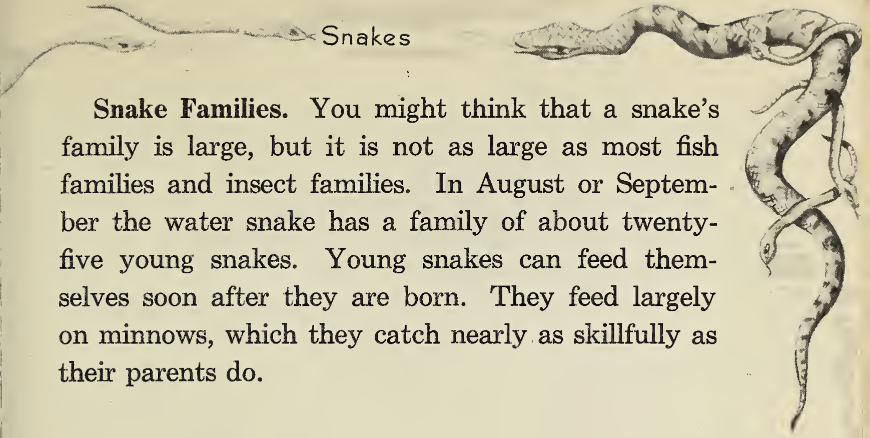
Snail

In June the mother snail finds a pit in the ground. Here she places about forty white eggs which she covers with earth. After they are hatched, some snails eat their own eggshells. Snails have a better chance to live than young fish and tadpoles have.

Insect Families. Certain insects lay their eggs where the young will have something to eat when they are ready for food. Flies lay their eggs on any kind of vegetable or animal waste. One fly may lay as many as five hundred eggs. After they hatch, the young flies find plenty of food around them. After two weeks many of them have become adult flies. Flies would survive in great swarms if man did not get rid of them by various means.

Katydids, ladybugs, and black swallowtail butterflies lay their eggs on leaves that serve as food for the young. Then off go the parents, and leave the young ones to grow up without their care.

Ladybugs


Snakes

Snake Families. You might think that a snake's family is large, but it is not as large as most fish families and insect families. In August or September the water snake has a family of about twenty-five young snakes. Young snakes can feed themselves soon after they are born. They feed largely on minnows, which they catch nearly as skillfully as their parents do.

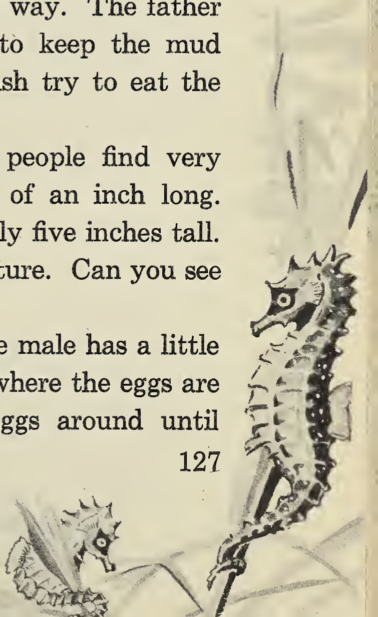
Certain Animals Carefully Guard Their Young

Some fathers of large animal families watch over their young. The male sunfish usually makes the nest in which the mother lays her eggs. As soon as the eggs are laid, she swims on her way. The father then fans the eggs with his fins to keep the mud from settling on them. If other fish try to eat the eggs, he will fight them off.

Young sea horses, which most people find very interesting, are about one-fourth of an inch long. Even the largest sea horse is scarcely five inches tall.

Look at the sea horses in the picture. Can you see how the sea horse got its name?

Sea horses guard their eggs. The male has a little pouch on the underside of his tail where the eggs are placed. The father carries the eggs around until


Sea horses

Male stickleback

they are hatched. Then he pushes the tiny fish out of the pouch.

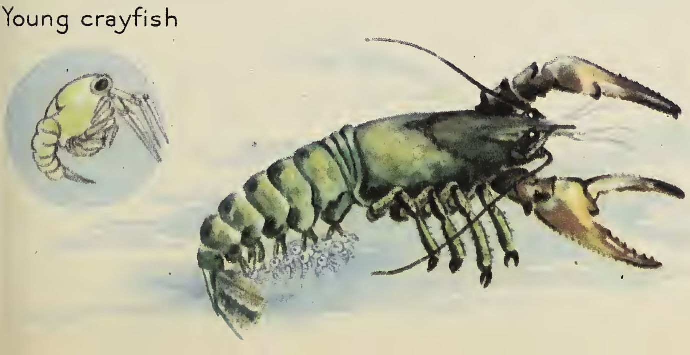
A male stickleback is another kind of fish that guards its eggs. A male stickleback builds a nest of tiny bits of stick among the stems of water plants by fastening the sticks together with a sticky liquid from his body. The stickleback fish has a row of sharp spines on his back to protect him from his enemies. No wonder some fish are afraid of this good fighter!

After a nest is finished, several female sticklebacks may lay eggs in it. Not one of the females stays to watch over her eggs. Instead, the male stickleback guards the nest and keeps new water traveling through it. First he blows water into one door of the nest, and then he swims around and blows water into an opening on another side. After the eggs hatch, the father continues to take care of the young fish. When the young ones go too far from the nest, he chases them back to their home.

Careful Parents

Crayfish. Crayfish also guard their young. The eggs are fastened to the mother's body by a sticky substance. From these small white eggs come strange-looking young crayfish with eyes that are very large compared with the size of their heads. Their tails are very small. As the little crayfish grows older, it looks more and more like its parents.

After they are hatched, young crayfish may cling to their mothers for a short time. Then they crawl away and burrow under rocks or logs in fresh-water ponds and streams, just as their parents do.



Birds. Everyone knows that bird parents take good care of their young. Most kinds of birds build nests. Every different kind of bird makes a different kind of nest. Many people can tell by looking at a nest what kind of bird built it. What birds do you know? Out of what materials does each kind build its nest?

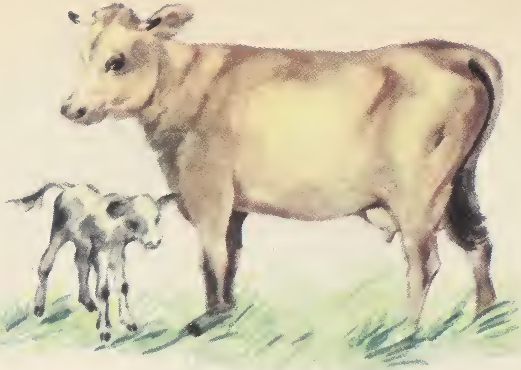
Kangaroos. Kangaroos carry their young in a pouch, just as the sea horse and some kinds of frogs do. Usually the kangaroo mother has only one baby. It is only about one inch long when it is born, and is as blind and furless as a baby mouse. If it were not protected by its mother's pouch, the young kangaroo would probably die.

Sometimes kangaroo mothers with their young can be seen in a zoo. Keepers of the Philadelphia zoo believe that kangaroo mothers are not able to take care of more than one baby at a time. One day they found a baby kangaroo on the ground in the kangaroo cage. It was much too young to leave its mother's pouch. Since each kangaroo mother in the zoo was carrying a baby in her pouch, the keepers decided that the baby kangaroo on the floor must be a twin. If the mother was uncomfortable with two baby kangaroos in her pouch, she might have pushed one of them out.

The little orphan kangaroo was placed in a special room at the zoo and fed milk from a bottle. For several weeks it grew like the other little ones. After it was about two months old, however, it became ill and died.

The other kangaroo babies stayed in their mothers' pouches until they were two months old. Then they began to stick their heads out of the pouches to nibble at the tall grass that their mothers brushed against. After two months a young kangaroo is about a foot high and able to hop about. But it is still very timid, and when frightened will hurry back to its mother's pouch.

Cows. Newborn calves are not as helpless as baby kangaroos. They can stand on their wobbly legs almost as soon as they are born, but they must depend upon their mothers for food and care. When



a cow is separated from her calf, she may bellow for it all day long as she feeds in the pasture. A mother cow can find her own calf among hundreds of others.

Deer. A doe also watches over her young deer, and takes care of them until they are full-grown. She leads her fawns through the forest and helps them to avoid enemies. Sometimes she will hide her twins or triplets in separate spots and will go back and forth from one hiding place to another, taking care of each little fawn. If a poisonous snake should attempt to attack one of the fawns, the doe

will bound into the air and come down on the snake with all four of her horny hoofs.

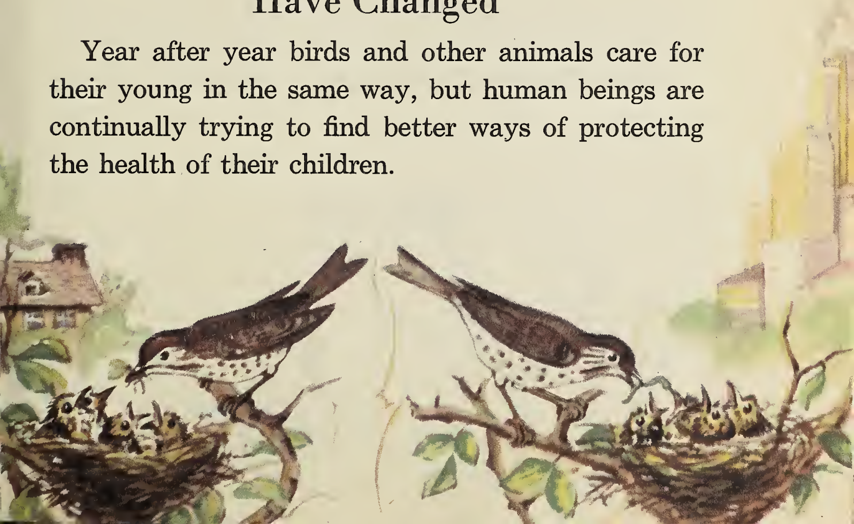
Many Kinds of Animals Are Careful Parents. Sheep, monkeys, and elephants are a few of the animals that are careful parents. Their small families are born in a rather helpless condition, but are taken care of by the parents until they can get along well by themselves.

The length of time the parent needs to protect her babies varies among animals. A mouse can get food and protect itself a few weeks after it is born, but young elephants may stay with their parents many years.

How long do human parents take care of their children? What kind of care do you still need?

Ideas about Caring for Children Have Changed

Year after year birds and other animals care for their young in the same way, but human beings are continually trying to find better ways of protecting the health of their children.



If you had lived in colonial times, your doctor would not have treated a cold as a doctor does today. In those days the doctor would have told your mother to tie a little bag of camphor around your neck, and he would have allowed you to go to school. People also tied woolen socks around their necks to try to drive away their colds. In colonial days people did not know as much about the body or how it works as they know today. Today parents, doctors, nurses, dentists, and teachers all are interested in helping you to take care of your health.

Scientists have studied and experimented many

years in order to learn how to cure just one disease. Each year they try to discover better ways of curing those who have mumps, measles, chickenpox, and other diseases that you hear about. There are large libraries full of books that tell only of the things scientists have learned about taking care of diseases.

By using the ideas that scientists have proved to be good, many lives are saved today. In the United States alone, thousands of babies who are living this year might have died of various diseases if they had been born twenty years ago. Also by preventing babies from having certain diseases, a greater number of them that are born each year have a chance to live.

Through the years human parents have learned, from the work of scientists, better ways of taking care of their children. But birds and other animals follow their old ways of survival.

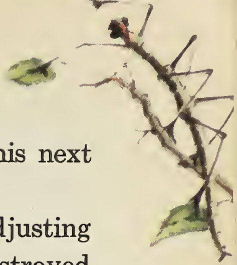
The Skills and Adaptations of Animals

After the baby oyster and baby kangaroo have survived their childhood, they have more difficulties to overcome if they are to live. All animals at some time have to struggle hard to survive. The young kangaroo develops powerful back legs with which to spring away from its enemies. The use of claws, flappers, horns, tusks, or teeth is the means of keep-

ing many animals alive. For its world, the duck needs a webbed foot. What helps the elephant, the hawk, and the elk in their struggle to live?

Many animals that are not good fighters have sharp eyesight or keen hearing. Some animals move more speedily than their enemies and thus avoid them. Like the squirrel, some have learned to climb trees and to jump from branch to branch away from danger. When in danger, a mole will burrow farther underground; a frog will jump into the water; a bird will take to the air; and a porcupine will use his bristles. You have often noticed these skills without thinking how useful they are to the animals that use them.

Suppose a rabbit were born without the bounding speed of his cottontail brothers. When a hungry fox roams his way, the slow-poke bunny will certainly be the one that will be caught. Or imagine a squirrel that cannot climb a tree. When an enemy comes


Walking stick

his way, at least one squirrel will make up his next meal.

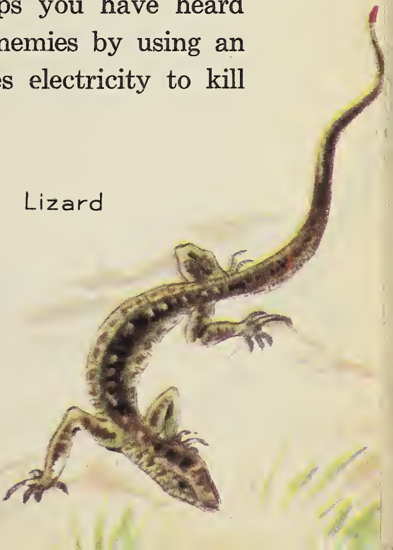
The special means that animals have of adjusting to their world so that they will not be destroyed are called adaptations.

Strange and interesting means have been used by animal families in their attempt to live in dangerous surroundings. Certain creatures try to remain perfectly still, so that their enemies will pass them by. The opossum is an animal that makes believe that it is dead when an enemy approaches. A chameleon changes color to hide itself against its background. Modern armies learned the art of camouflage from the protective coloring of animals.

The walking stick and the praying mantis are insects that look very much like the twigs on which they make their homes. Perhaps you have heard about the fish that avoids its enemies by using an ink-screen and another that uses electricity to kill

Porcupine

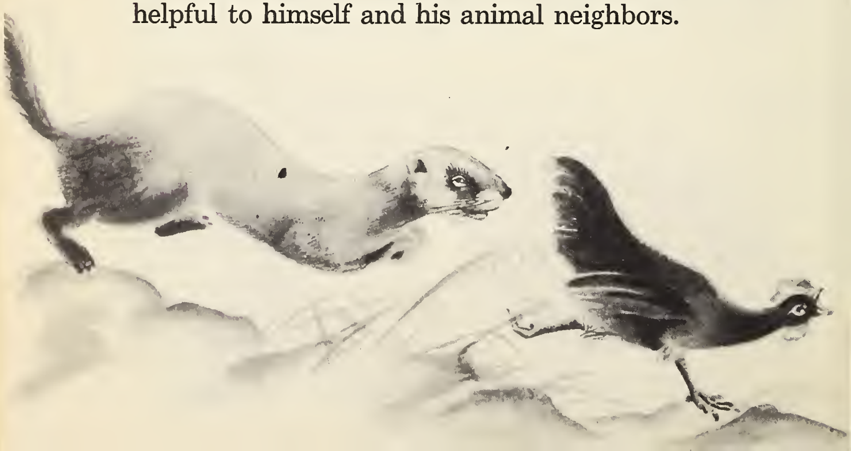
Lizard



its enemies. Look at the picture of the porcupine and the lizard on page 137. How do they protect themselves?

It is very important to remember that animals use these adaptations as means of obtaining food as well as of overcoming their enemies. For example, the mantis may remain quiet to catch its food or to fool its enemy; the octopus may discharge its ink in order to hide from its attacker or from the fish it will attack.

Man cannot carelessly interfere in the animals' struggle for life without making mistakes. If he brings an insect from one region to kill an insect in another, he must be certain that the new one will not become a worse pest than the first. The farmer who brought to his farmyard a small animal called a ferret to destroy the rats there discovered that the ferret got rid of his chickens after the rat supply was gone! Man must know a great deal about animal life before he can make any changes that will be helpful to himself and his animal neighbors.



WHAT DO YOU THINK?

1. Scientists have found many new ways to treat diseases. They have increased your chances to live for a long time. Do you think many animals have improved their ways of caring for their young?

2. What means of adaptation do beavers, squirrels, and giraffes use? Make a list of other means used by these animals.

3. Will the use of DDT to kill insects make new problems for mankind? What might some of these problems be?

THINGS TO DO

Choose an animal that you can conveniently study. It might be a chicken, a canary, a cat, a dog, a goldfish, a salamander, or a turtle. Write down all the means the animal you have chosen to study uses in adapting to his surroundings. Compare your list with that of a classmate.

How Friction Helps or Hinders Our Work

Machines Make Work Easy

Man's way of caring for his children is superior to that of other animals. And so is his way of doing work. Man alone has learned to use machines. Before he learned how to make these machines, he had to use his muscles or the muscles of animals to get his work done. These methods usually took a much longer time than machines take.

Notice the picture of the pyramid on the opposite page. It covers thirteen acres—many times the space occupied by your school and playground. It is more than four hundred feet high, weighs about seven

million tons, and is composed of more than two million separate blocks. This is one of the wonders of the days when man used muscles to do most of his work. It is believed by men who study such things that this pyramid at Gizeh, Egypt, must have taken at least one hundred thousand men twenty years to build. Think of how these thousands of slaves had to push and strain at each of those blocks!

Now look again at the picture at the beginning of this chapter. Think of the progress we have made in learning to work without using great physical effort.

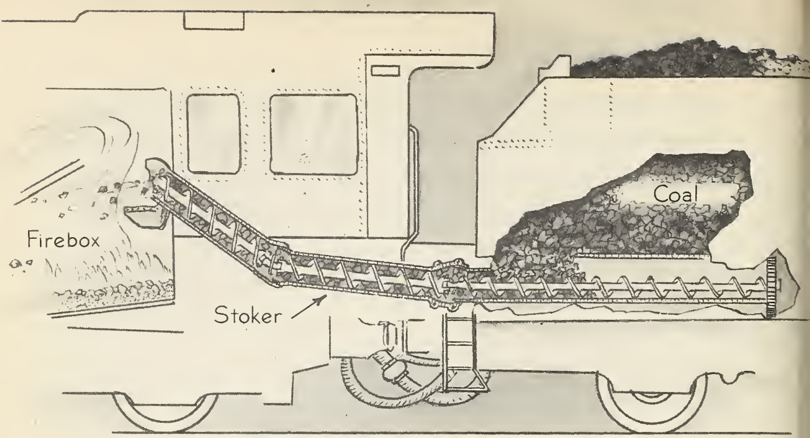
There was a man in ancient Greece who once said, "Give me a place to stand, and I will move the earth." Of course it was impossible to give him such a place; therefore it was impossible for him to fulfill his promise. This man was Archimedes, who was one of the earliest men to experiment with machines that would help man to get his work done without using as much energy as he otherwise would need. Since Archimedes' time man has experimented with machines of all kinds, from a clumsy plow to a mighty locomotive.

But not one of these machines will work alone. We must use our muscles or some substitute for them as the force, or source of power, that pushes or pulls or turns the machine. The inventors of the last hundred years have made many wonderful discoveries about the source and use of power. Instead of inventing new ways for us or slaves or animals to use muscle power, these men have found new sources of power. They have learned that steam, water, electricity, coal, gasoline, and oil can furnish far more power than great numbers of men or beasts. Let us look at one of the best examples of man's use of energy that is stored up in nature.

How a Locomotive Works

A locomotive is a machine that is made of many machines. It has many wheels and rods in it. Some locomotives use oil as the source of power to turn their wheels, some use electricity, and some use steam. Since the way steam turns the wheels of a locomotive is rather simple, let us think about this method first.

Coal Supplies Energy. Perhaps you have seen the fireman as he shovels coal into the firebox of a locomotive. Shoveling coal is hard work, but it would be harder still if the fireman did not use a tool which we call a shovel.



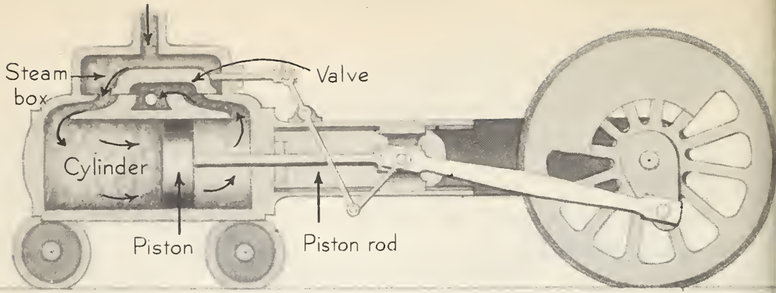
Some steam engines in locomotives use as much as six tons of coal in one hour. A man can shovel about two and a half tons of coal in this length of time. This is not enough to keep a heavy train moving fast. Many trains use a special kind of machine, called a stoker, to keep their fires supplied with coal.

Stokers can feed fire with coal much faster than a man can with a shovel. In a stoker coal rolls along a large screw, which turns and pushes the coal forward. Look for the stoker in the picture above.

After the stoker has fed the coal into the firebox of the locomotive, much water must be heated by the fire to make enough steam to turn the great wheels. Sometimes flames shoot through the pipes and sometimes surround them; and the water in the boiler changes to steam.

Steam Pushes. Large amounts of steam push against the sides of the boiler. The boiler walls must therefore be very strong, so that the pressure from the steam will not make them burst. Because steam pushes very hard, we can make it work for us.

You can put steam to work in a test tube or in a pyrex bottle. Put about an inch of water in the bottle. Insert a cork that just fits the top, but do not push it in too tightly. Your face should not be near the top of the bottle. Heat the water until some of it turns to steam. You will see that steam fills the bottle, because steam takes up more space than water. Steam spreads out so much that one bottle full of water would fill 1750 other bottles like it full of steam. So, as water turns to steam in the bottle, the steam pushes because it needs more room



in which to expand. It expands until—all at once out goes the cork with the steam after it!

Steam Moves Pistons. In the same way that it pushes the cork, steam can move metal pieces, or pistons, in the large metal tubes of an engine. These tubes are called cylinders. A rod connects the piston to a wheel, and the wheel turns part way around as the rod moves.

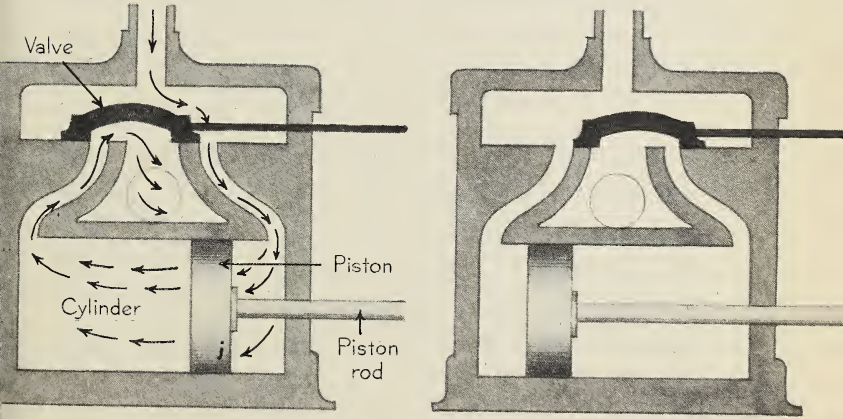
After steam has pushed the piston, it becomes dead steam. It cannot push as hard as when it was live steam. Dead steam is not as hot as live steam.

In a locomotive, live steam pushes the piston rod back and forth. If this steam pushed the piston only one way, the wheels would not move far. Machines are made so that steam pushes the piston back in much the way that it pushes it forward.

Follow the path of the steam in the picture. The live steam goes through the tube into the cylinder and pushes the piston to the other end of the cylinder. As the piston moves, the piston rod pushes the wheel part way around. After the steam has pushed the piston, it leaves the cylinder as dead steam through the tube which is shown as a circle in the center of the picture below.

A movable piece of metal called a valve is connected to the piston rod. As the piston moves forward this valve moves back in such a way that the valve closes the place where the steam was entering. This stops the steam from entering on this side of the piston. But now the steam can enter through the opening on the other side.

Follow the new path of the steam. New steam pushes the piston in the other direction. As the piston moves, the valve moves again. So the steam rushes into the cylinder, first from one side, then



from the other. In this way many pistons are pushed back and forth, back and forth, and the wheels which are fastened to the piston rods go around and around.

When a train is starting, there is not a great quantity of steam to push the pistons back and forth. Each push of the piston sends enough dead steam out of the smokestack to make a noise that sounds like choo! As the steam pushes the piston back and forth more rapidly, the choo-choo comes faster and faster.

In similar ways, by using steam, electricity, and other forms of energy, man operates many kinds of machines. He makes almost everything he wears with machinery. He makes the books he reads, the toys for his children, the furniture he uses. He prints your report card; he turns out your baseballs; he shows you movies—all with machines.

Friction Stops You

Once the big locomotive is started along the rails, will it travel on and on forever? Can the fireman stop shoveling coal and turn off the steam? Will the locomotive keep going? Your common sense tells you that if it could go without power, railroad companies would certainly run their trains that way.

Perhaps you can try an experiment to check your common sense. Start your own toy locomotive on its track, and then turn off the electricity.

Or you can try another experiment, this time on yourself. Go down to the pond when the ice is thick and get one of your friends to start you off on the ice with a push. Away you go, skimming along at a great clip! But after a little while you will stop sliding. All the machines we have read about will also stop if the power applied to them is cut off. But what slows you and the train down to the stopping point?

The force that opposes the motion of the machines and of your body is called friction. Friction acts like a brake. Smooth as the ice may seem, little rough particles cover its surface. No matter how smooth you have worn the soles of your shoes, their surfaces are rough. The rubbing between the bumps on the soles and the rough places on the ice made you stop sliding. To see how rough the soles of your shoes are, look at them through a reading glass. The wheels of the locomotive, the rails, the metal parts of machines are not as smooth as they seem to be either. Every surface in the world is somewhat rough. So whenever two surfaces rub against each other, the friction thus caused will oppose motion.

Living without Friction

We can often understand things better by imagining how we could get along without them. So let us imagine ourselves in situations where there is no friction. Imagine that you are on a pond, standing on perfectly smooth ice. There is no rough surface for your shoes to push against. Since there is no friction,

you would not be able to walk on the ice without help of some kind.

You might call for help. But if there were no friction, no person could take the steps necessary to rescue you. Perhaps there is a rope lying within reach. It is attached to the shore. Your hopes are raised; but when you try to grasp it, you find that you are powerless to move your feet.

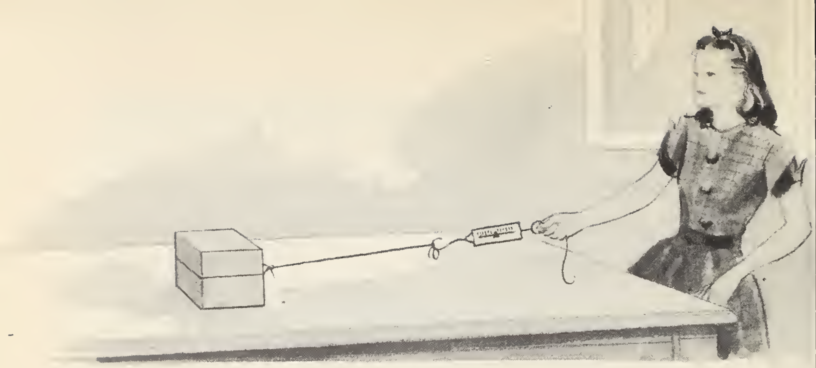
You begin to worry. Will you have to stay on this cold ice forever? No. For there is a way to start motion. You might try to move your arm as though you were going to throw something. This would give you enough motion to start you on your way. There would be enough friction between your arm and the air pressing against it to start you off.

If you were in a frictionless world, you would not be able to walk, no wheels could turn, and no vehicles could come for you.

Our world without friction would be quite unlike anything that we know.

More or Less Friction

There is more friction between moving rough surfaces than between moving smooth ones. You can prove this by pulling a heavy block of wood over a smooth surface and then over a rough one.



Perhaps you can fasten a block of wood to a spring balance. Notice how much force it takes to pull the block along a smooth table top. Then fasten a piece of sandpaper on a table so that the scratchy side is up. Pull the same block of wood across this rough surface.

Pulling the block of wood over the rough surface makes more friction. The bumps in the block of wood catch in the bumps on the other surface. More of them catch when the wood travels over the sandpaper than when the wood moves over the smooth table top.

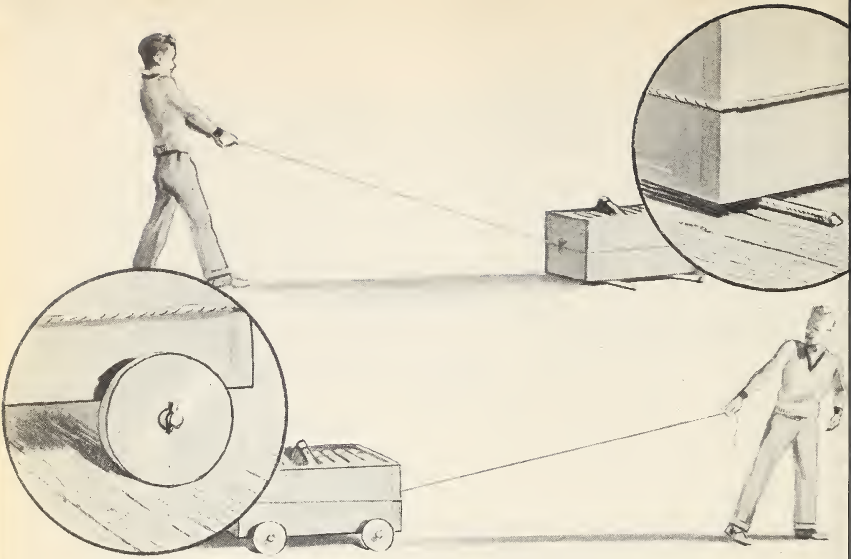
Can you understand why there is more friction between rough surfaces than between smooth ones? Look again at the pictures of surfaces in this chapter. You can see that the raised places on very rough surfaces are more likely to catch on each other than when the raised places are not so large and there are not many of them.

Would you rather pull a log that has rough bark through matted leaves or pull a smoothly polished pole over a piece of glass? Of course it is easier to pull something when the surfaces are smooth, because there is less friction. But no surface is completely smooth; there are always uneven places on it even though they cannot be easily seen. Between moving parts there is always a certain amount of friction, but the rougher the surfaces, the greater the friction.

Rolling and Sliding Friction

Long, long ago men pushed and dragged their heavy burdens along the ground. It was difficult, because there was so much friction between the moving burden and the rough road. No one knows when men learned to roll things on wheels. Perhaps a man rolled a log downhill and noticed how much easier it moved than when he pulled the log along. Perhaps a heavy sled happened to pass over a log which was lying on the ground so that the log rolled while the sled was on it. Then heavy things were placed on logs and rolled across them. As they rolled, the logs which were left behind were carried around and put under the front of the load.

When a box full of books is pulled across the



floor, it must get over the bumps and hollows on the surface of the floor. It is hard to pull the heavy box, which is flat against the floor, because the rubbing of the surfaces causes much friction. When one surface slides over another, the friction between them is called sliding friction.

Try putting round sticks of wood such as broomsticks under the box. Do the rollers help? It is troublesome, though, to keep placing the rollers properly as you move the box along.

Moving along rough surfaces was made easier when man learned to fashion rollers in the form of wheels.

Rollers and wheels move more easily over the surface of the floor than the flat bottom of the box does, for there is not as much friction between the rounded surfaces and the floor. This kind of friction is called rolling friction.

Since surfaces that roll do not catch onto as many rough places as flat surfaces do, objects that roll cause less friction than objects that slide.

How much easier it is then to roll something over a rough surface than it is to slide it!

Heat from Friction

Friction from rubbing rough surfaces together makes heat. Rub your hands together for a few seconds. Do you feel the heat that has been produced? Look at the skin on your hands. Do you see any rough spots on your skin? Have you ever had a blister on your hand or on your foot that was caused by friction?

The next time you roller-skate, feel the wheels of your skates after they have been rolling fast over the pavement. The wheels become warm from the friction between the pavement and the rollers.

Can you feel the heat produced when you rub hard on a piece of wood with sandpaper?

Perhaps you have felt a saw after using it to saw through a board. Friction has made the saw hot.

Have you ever started a fire with the heat of friction—by rubbing two sticks together? There is friction when any two rough surfaces pass over each other, but sticks must be rubbed together for a long time before enough heat is produced to make them burn. If you have made a fire in this way, you know that you have to rub and rub before the sticks get hot enough to make a spark.

If there is a Boy Scout in your class who has a Scout Fire Drill Set, ask him to show you how it works. When one end of a stick is twirled rapidly in a hole that is made in a flat piece of wood, some of the wood will be ground into fine pieces of wood dust. The twirling of the stick will also produce friction.

The wood dust can be easily set on fire by the heat of friction. The dust will not have to become as hot as a large piece of wood does before it will begin to burn.

Using matches is a quicker way to build a fire. Friction between the head of a match and the surface on which it is rubbed produces heat. Powdered glass is used in most match heads to increase friction. This glass is ground into pieces too small to be seen. The chemicals on the head of a match do not have to become very hot before they begin to burn. When a match is struck hard, there is enough heat from the friction to start the chemicals burning immediately.

We see that friction helps us by starting fires. Think of all the ways fire is used to help you. Would you miss fire in the wintertime? Would you like to eat only raw food?

We have not thought much about the friction caused by the air and whatever travels through it. Meteors pass through the air at a very rapid speed. Think how much friction there must be between the air and these falling bodies. So much heat is produced that the meteor flames and glows with light. In fact most meteors burn up before they reach the earth.

Friction Causes Wear

When you run or walk, friction between the sole of your shoe and the ground knocks off some of the little uneven places on each surface. More and more uneven places are scuffed off until there is no leather left in the place that rubs hardest on the ground. Friction has worn away the leather, and it has worn the surface of the ground.

In a similar way friction wears away not only the wood but the sandpaper that scrapes it. With the wood dust will be grains of sand. Can you tell how friction causes the wear?

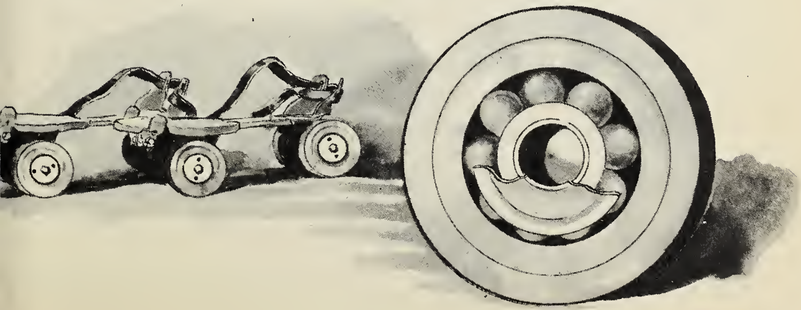
Perhaps you have worn some of the skin off your fingers or made a blister on your palm by sliding down a rope or a tree. When this happened, you felt the heat of friction.

When you write on the blackboard, small pieces of chalk are left on the surface of the board. Even though the blackboard feels smooth, there are small bumps and hollows all over it. The surface of the chalk is somewhat rough, too. So the rough places on the piece of chalk catch on some of the rough places on the blackboard. The soft chalk leaves a mark on the board which can be taken off with a board eraser. You can see then that there is friction between the chalk and the blackboard and between the blackboard and the eraser.

Reducing Friction

Friction wears the moving parts of machines even though they may be made of hard steel. The parts worn down by friction must be replaced or they may cause harm. Most machines do less work when their surfaces become rough and their parts become worn. When one part of a machine turns against another one, there is friction, and the more friction between parts, the slower the machine will move. Perhaps you can visit a garage. Ask the garagemen to show you some parts of an automobile that have been so worn by friction that they can no longer be used.

Ball Bearings Reduce Friction. There are several ways to reduce friction. Ball bearings are used in your roller skates so that they will have rolling friction. Small metal balls are used between the axle

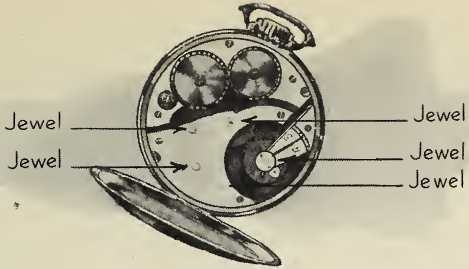


and the wheels. As the outside wheel turns, it rolls over the metal balls instead of rubbing against the axle. In turn, the metal balls roll on the axle, reducing the sliding friction still more. All the moving parts roll. Since friction between rolling parts is less than friction between sliding parts, the ball bearings in your skates reduce the rubbing.

You can travel fast if there are ball bearings in your skates, because there is little friction to hold you back. Perhaps you can take a worn skate apart and look at the metal balls in the wheels. Ball bearings are used in bicycles, sewing machines, and record-players.

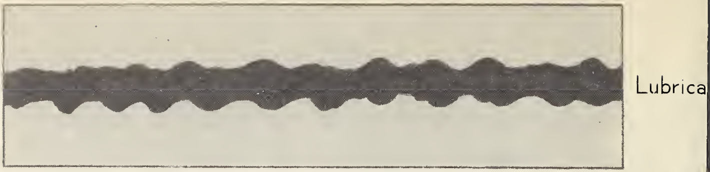
Smooth Surfaces Reduce Friction. Friction is sometimes reduced in another way. As we know, there is less friction between smooth surfaces than between rough ones. Therefore if we can polish a surface very smooth, the possibility of causing friction will be reduced. Certain metals can be polished to a glass-like smoothness. Special metals called bearing metals are used in moving parts of machines because these metals have the power to keep their smooth surfaces. Hollow places do not wear in them as rapidly as in most other metals.

Have you ever heard people talking about seventeen-jeweled wrist watches? They do not mean that



the watches have jewels set in their cases. Jewels are used inside the watches at the points where parts rub together. Watchmakers use jewels, such as rubies and sapphires, for some of the turning parts in a watch. Sapphires and rubies are harder than steel. Friction between the moving parts does not wear hollow places in the jewels as fast as it would in metal parts. Watches having a large number of jewels in them usually last a longer time than watches made entirely of metal.

Lubrication Reduces Friction, Too. If you have stepped on a banana peel, you probably know that the oil in the skin reduces not only friction between it and the sidewalk but also between your shoe and the skin; and this lack of friction makes you slide. Maybe you never thought of it in that way. Substances like oil, grease, and wax are called lubricants because they make surfaces slippery. Even water might be considered a lubricant at times. You know that rain makes a road slippery. Automobiles skid



more easily on a wet surface than on a dry one. The reason for this is that water makes the surface smoother, so that there is less friction between the tires and the road.

Examine the diagram on this page. Here is a picture which enlarges two rough surfaces separated by a layer of oil. This oil helps to fill in the little hollows so that the rough surfaces will not catch on each other easily. A lubricant makes a film between the moving parts. In fact the moving parts may not touch each other at all.

In a similar way ice makes a better slide than smooth glass. When you stand on ice, a small amount of it melts. Then there is a coating of water on the ice and on your shoes. The water reduces friction, because it fills in the hollow places and covers the rough places. It keeps the solid surfaces from rubbing very much.

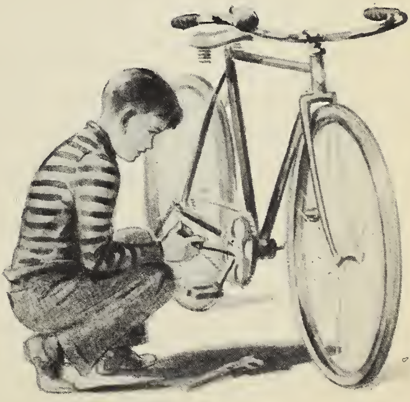
Sleds travel over ice more easily than they travel over glass. The pressure of the metal runner of a sled melts the ice a little, too. The melted ice coats the surface of the sled runner, and the water acts as a lubricant and reduces the friction. When you skate, coast, or slide on ice you do not notice the melting of the ice because the water freezes again right away.

Perhaps you can cut an ice cube by pressing on the ice with a thin wire. The ice under the wire melts. The top of the ice cube will freeze again so that the wire is frozen in its center. So you see that freezing occurs when friction is removed.

Large quantities of lubricants are being used every day to control friction that might hinder our work. The axle of every wheel in a locomotive is bathed in oil. Trains are inspected from time to time while they stop at a station. Have you watched men working on the trains with their tall oil cans?

Many men work in factories trying to reduce the amount of friction between the moving parts in machines. Some of these men oil the parts of the machines; others spend many hours trying to find ways of building machines which will have less friction between their parts.

Do you remember to lubricate the moving parts of your bicycle? Do you keep a little can of oil for your toy locomotive? Do you know what to do when the hinge on your door



creaks and makes strange noises? The oiling of the motion-picture machine, the refrigerator, the clock, the locks on the door, are uses of lubrication that you can observe at home or at school.

But no one would want to get rid of friction entirely, for at times it can be very helpful. We would find ourselves in great difficulty without it.

Friction Often Helps Us

From our story about the imaginary world without friction we can understand that friction is useful. We have learned, too, how important friction is in producing fire. It has been mentioned that our use of nails and screws and pencils and chalk depends on friction.

Yet much of this chapter describes how friction may hinder us. We have just been hearing of ways to reduce friction. We have heard of white-hot meteors, of worn machine parts, burned-out bearings —all of which have been affected in some way by friction.

Friction can be helpful or harmful. Man can use it to his advantage. He has made the surfaces of tires rough just to cause friction. When tires are smooth, automobiles and bicycles are more likely to skid. In mud, in deep sand, and in snow, wheels may spin around and around. Man uses chains on

tires to increase friction; chains make the surface rougher and thus the wheel is held to the road better.

The first trains ran on wooden tracks, which were rough. There was enough friction between the wooden rails and the train wheels to prevent slipping. When men first talked about using metal tracks, some people laughed. They said that the wheels on trains would just spin around without moving ahead and that there would be so little friction that the wheels could not travel over the tracks.

Of course we know that trains can travel over metal rails. But when it sleets and a film of ice forms on the rails, engineers often have to sprinkle sand over them.

Sometimes a trolley car will not start on wet tracks unless sand is scattered on them. Sometimes sand must be used on tracks laid on a steep hill even though they are dry.

Have you any shoes that are made so that there

will be much friction between their soles and the ground? The rubber soles of gym shoes and the spikes on baseball shoes increase friction and keep you from sliding. Here friction helps you.

Do you ever use friction as a brake when you are bicycling down a hill? Brakes of automobiles and trains depend on increased friction, too. Pressure between a moving part and a still surface increases friction. Travel would not be very safe if we could not use friction in this way.

A knowledge of friction helps us to increase friction when it can be helpful to us and to reduce friction when it will hinder us.

MORE THINGS TO DO

1. Examine the brakes on an express wagon. Tell how they make use of increased friction.

2. Try to write on smooth glass with a pencil or with chalk. Then try to write on frosted glass. Explain the difference.

3. Look around your home for places where people might slide. Can you do something to increase friction and safety at these places?

WHAT DO YOU THINK?

1. How does friction help you when you make a mistake while doing arithmetic? Friction helps you when you write with a pencil. Think of other ways in which friction has helped you today.

2. How different would your world be if man had not learned to use friction to his advantage?

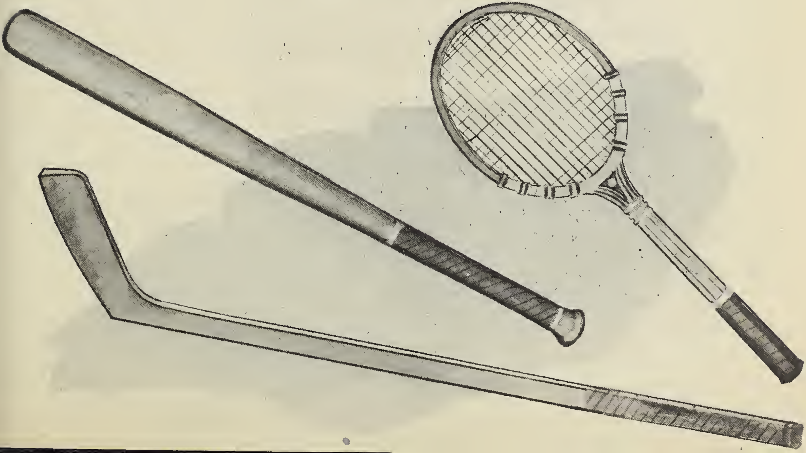
3. Lubrication is usually desirable. What is undesirable about getting the lubricating oil on the brakes of your car?

4. Is friction helpful or harmful?

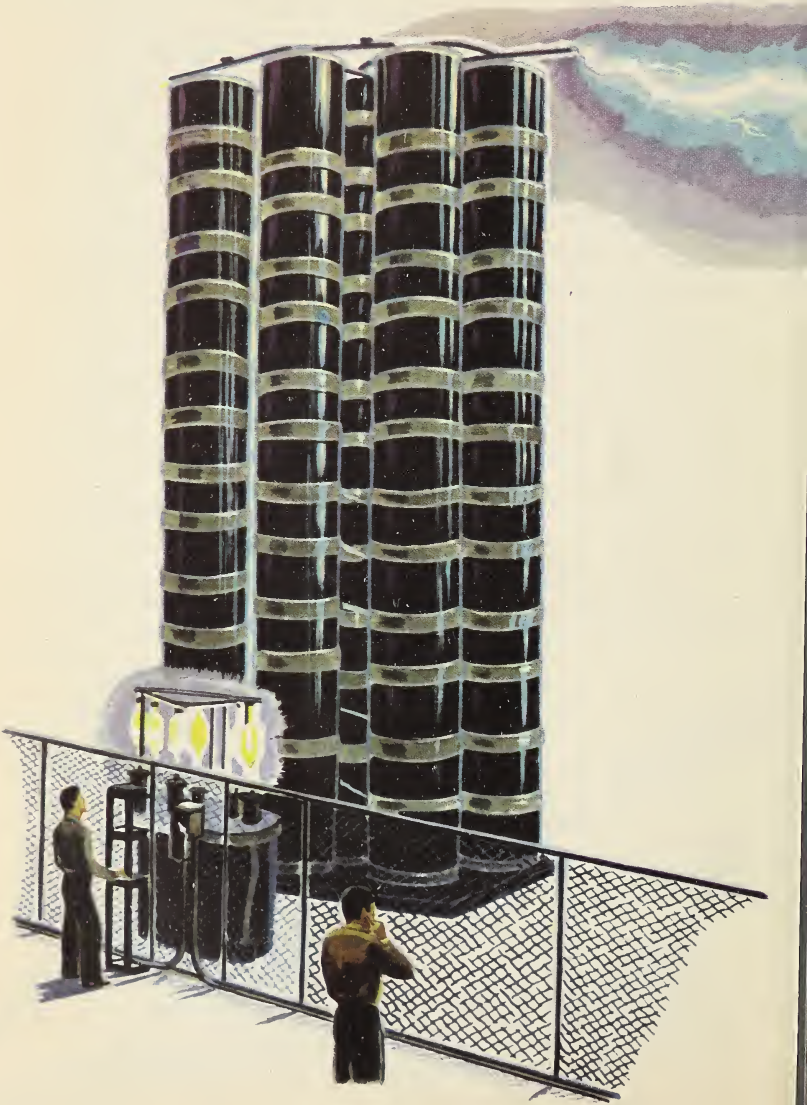
5. More accidents occur in homes than in any other place. Which ones occur because of friction? Which ones occur from a lack of friction?

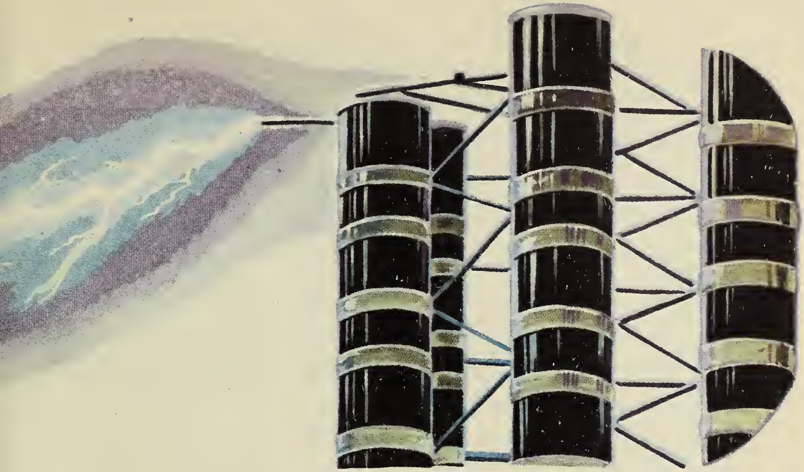
6. Friction always produces two effects: heat and wear. How do you make use of these effects?

7. Why is tape wound around the handles of baseball bats, hockey sticks, and tennis rackets?



Electricity Works for Us





Friction Makes Electricity

At the end of the last chapter you read of the part friction plays in the world about us and of the need to know more about it. You may not have thought when you read the title of this chapter and looked at the picture that introduces it that friction was going to appear again.

If you can remember your first experiences with electricity, you will probably discover that the electricity you first wondered about was produced by friction. Perhaps you did not become interested in what produces electricity, however, until by accident you produced electricity yourself. One cold winter day when you stroked your cat's fur, it crackled and stood waving against your hand. If you were in the dark you probably saw tiny sparks. At another time maybe you rubbed your fountain pen over your wool sweater and were surprised that the same crackling resulted. Even when you combed your own hair that sharp snapping sound may have been heard. Or when you spread another blanket over your bed that same winter's night, the crackling and sparks may have been there again.

Sometime you may have played with this kind of electricity when you shuffled across a carpet and touched an unsuspecting friend with your fingers. The crackling noise and the tiny shock are known to all of you. This electricity, which is produced by rubbing things together, is quite properly called frictional electricity. It may be as tremendous as a lightning flash or as tiny as the spark that skips from

the cat's back to your hand, but it is the same thing. The spark from the cat's fur is frictional electricity traveling from the cat to you. The lightning of the sky is also frictional electricity, traveling from cloud to cloud or from cloud to earth.

Lightning Is a Giant Spark

Scientists in recent years have produced sparks some of which are stronger than the lightning of a summer storm. The picture at the beginning of this chapter shows men experimenting with the giant sparks. They have spent much money and a great deal of time and study in making the strange-looking instrument that produces man-made lightning.

You may wonder why scientists have spent so much time and money in learning to make these sparks. What good are they? Have the scientists found any use for them? Scientists are interested in facts that they believe will be useful at some time. Sometimes the ways in which facts may be used may not become known even to scientists for years after they are discovered. Therefore the scientist who first discovers facts will check and recheck them so that his records will be accurate. Someday when another scientist needs these facts, he will be able to use them without rechecking them. Scientists recorded many, many facts that later proved useful to the men who worked on the electric light bulb.

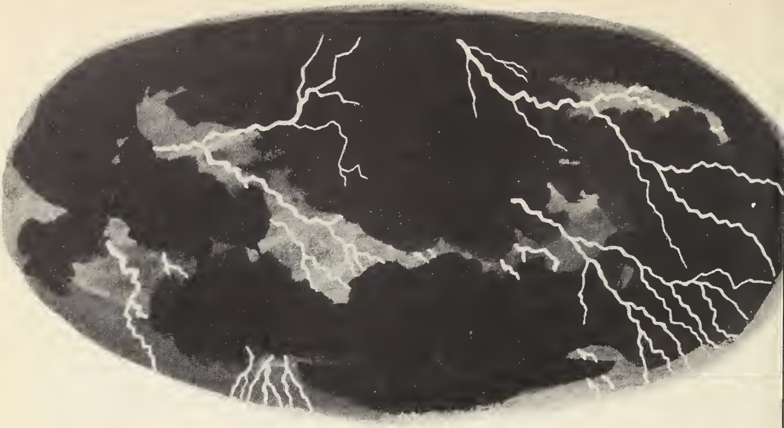
Before we could enjoy electric lights in our homes as we do today, scientists experimented with many kinds of fine wires to determine the glow that electricity would produce when it passed through them. Other scientists were working on an entirely different matter. They were keeping careful, exact records of how much different kinds of wires would expand when heated. Still other scientists were experimenting on ways of getting all the air out of a glass bulb. Another group of scientists was trying to burn substances in various kinds of gases. Dozens of other scientists had a part in producing the cheap, long-

wearing, electric-light bulb you know so well. Some of the men who studied how much different kinds of wires will expand did not know when they carefully carried out their experiments that this knowledge would help the scientists who were working on the electric-light bulb. When the time came for the inventors to pass the wire of the lamp through the glass base, they had to find a wire that has exactly the same amount of expansion as glass. Otherwise the lamps would crack when heated. They took the facts which the scientists had found about wires and used them to make a successful electric lamp.

Every invention—in electricity, in medicine, or in any other science—is based on accurate facts. With sound facts to build on, a way is open for discovery.

Scientists know that the giant sparks that jump a half mile in the clouds and the sparks produced when you shuffle your shoes over the rug can be explained by some of the same facts.

What Causes Lightning? It may be difficult to understand how friction produces lightning in the sky. Perhaps an explanation will help. You know that the air is full of many bits of dust, water droplets, and gases of many kinds. As the water droplets rub against other droplets, as specks of dust rub against other specks or droplets, as gas molecules rush



through all these things, they produce friction. This friction charges all these things with electricity. It is the same kind of electrical charge as the charge you made by rubbing the cat's fur or rubbing the pen, or by scuffing your feet on the wool rug.

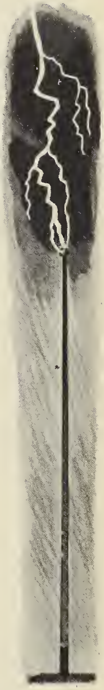
Each droplet of water is charged with a very small amount of electricity. Therefore when millions of drops of water have collected to form a cloud, the electricity in all the drops together may produce a very strong charge of electricity.

Electricity can travel over some things easily; other things make poor paths for electricity. Air does not make an easy path for electricity, but when the charge is strong enough, electricity will travel through the air. Electricity heats the air through which it passes so that you see a flash.

During a storm electric sparks travel from one part to another part of the same cloud in a fraction of a second. Some of the sparks will even travel from one cloud to another cloud.

When electricity travels from the sky to the earth during a thunderstorm, it may destroy the power lines that carry electric current to your house. Or the electrical sparks may start fires.

Electrical storms may occur in different places in the world at the same time. Right now more than a thousand thunderstorms are occurring. Perhaps it is a beautiful day where you are. Still, electricity is flashing through the air at many places every minute. Most of these flashes pass from cloud to cloud. Many strike the earth, but few people are killed by lightning. If you know what to do during a thunderstorm you can be quite sure that lightning will not reach you.



Paths for Electricity from the Sky. Be careful not to stand near a flagpole during a thunderstorm, because electricity sometimes flows easily toward high pointed objects. It is better to be rained on than to stand under a tree. A tall tree standing alone in a field may make a good target for lightning.

When electricity travels down a tree, it heats the sap and turns it to steam. Since steam takes up more space than water, the tree bursts.

Electricity travels through certain metals more easily than it does through the air. Since most metals conduct electricity easily, do not stand near them during a thunderstorm. An iron bridge may be as dangerous as a lone tree. Electricity from a cloud may use an iron bridge for a path to the ground. Wire fences are also dangerous for the same reason.

If you are in a train, however, there is little danger that lightning will strike you, because it is carried into the ground by the metal wheels. Electricity always takes the path that conducts it most easily.

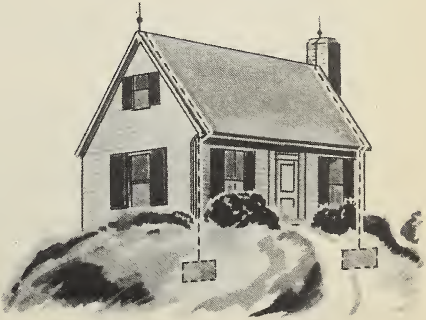
Most buildings are safe places in which to be during a storm. In many modern buildings the steel parts between the walls make good paths for lightning. But buildings with high steeples need special protection. A house with a pointed roof, particularly if it stands alone on the countryside, may make a good path for electricity coming from a cloud to the earth.

Taming the Lightning. You can see that the house in the picture was built on a high hill. One summer day a huge storm cloud formed in the sky above it. Tiny particles of dust were blown about violently. Wind swept through the tiny drops of water and gathered thousands and thousands of water drops together. They made a great storehouse of frictional electricity which grew larger and larger.

Suddenly there was a flash of lightning. There stood the pointed roof of the house high above the meadows. It was the easiest path for the electricity in the sky to take. Down the pointed roof it traveled. You know what happened to the house.

Another house was built in its place. Many people thought that the second house would be safe. They repeated the old saying: Lightning never strikes twice in the same place. They were mistaken. Scientists know that some places have been struck by lightning again and again. The men who rebuilt the house protected it scientifically from lightning by using lightning rods.

Lightning rods were fastened along the roof so that their points would be higher in the air than the roof. In this way a path was made for electricity if lightning should strike. No longer was the roof the highest point on the hill. The lightning rods stood above it. They would carry electricity into the ground.



Can you follow the path

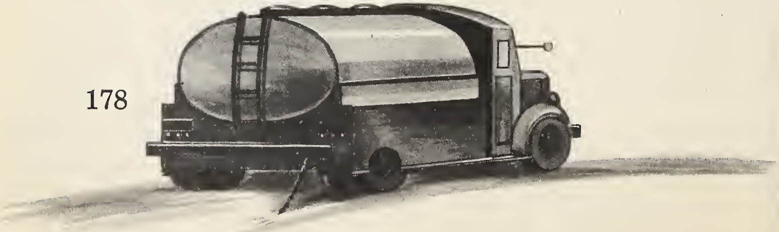
that lightning would take if it should strike the house protected by lightning rods? Wire runs from the rod to a metal plate that is buried in the damp earth beneath the surface of the ground. The plate is buried so that ground water will carry the electricity away from the soil near the house, then the metal will serve as a good conductor of electricity.

If lightning rods are not properly made, instead of carrying the electricity into the ground, they will lead it to the house. It is better not to have any lightning rods than to have poor ones.

Not many city houses need lightning protection, because they do not stand alone on a high point above the ground. Country houses and barns and church steeples need them. Can you tell why?

Other Paths for Electricity

Chains Can Carry Electricity. Have you ever noticed a chain dangling from the back of a gasoline truck? Perhaps you have heard an uninformed person say that the driver was careless because he allowed a loose chain to hang from his truck. However, just as the lightning rod carries the electricity

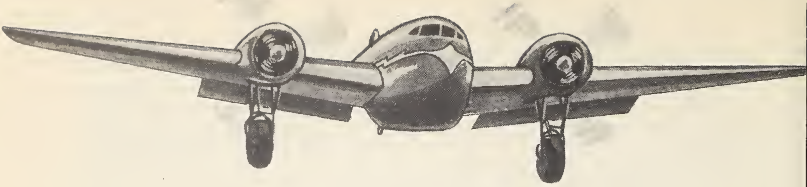


to the ground, the dangling chain is making a path for electricity to go from the truck into the earth without doing harm. But where does the electricity on the gasoline truck come from?

When gasoline trucks travel along the road, the gasoline inside them swishes back and forth against the sides of the tank. Electrical charges collect from this rubbing. A gasoline tank, then, is not a safe storehouse for electricity. Think what might happen if a spark jumped between the side of the tank and the gasoline?

Truck drivers are careful to have a path for electricity so that it will not collect inside the tank. Since metal is a good conductor, electricity can gradually leak down the chain into the ground. Watch for trucks with chains that carry electricity to the ground.

Tires That Can Carry Electricity. An airplane in flight builds up a strong charge of electricity that must be carefully controlled. Until recently there was danger of sparks that might cause fire when planes landed on the ground. If rubber tires were good conductors of electricity, the charge could pass harmlessly into the ground. But rubber is an insulator, which means that it keeps electricity from passing through it. Tires made of real rubber, then, would prevent electricity from leaving a plane.



For the sake of safety, scientists experimented with a new kind of tire that would conduct electricity. Today hundreds of airplanes come to earth safely on these new tires that make a path for electricity between the plane and the ground.

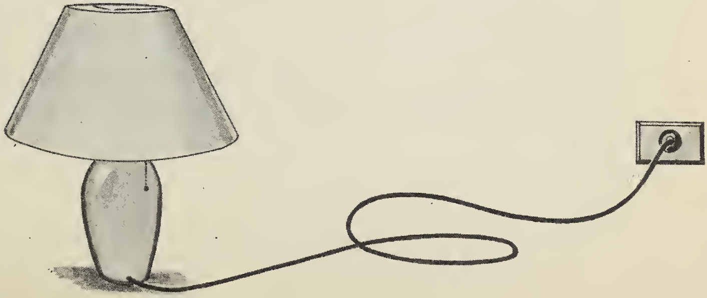
Gasoline trucks also make good use of these new tires. They no longer have to depend on chains, but travel on tires made of a new kind of rubber that carries electricity to the roads. The charge can flow through these tires because this new kind of rubber is a conductor and not an insulator. The old-style rubber tires on the gasoline trucks were dangerous because they were good insulators, and that is why the dangling chain was used. Enough electricity to blow up the truck might have gathered in the vehicle, because the rubber tire would have kept the electricity from passing to the ground.

You have seen that frictional electricity is produced by rubbing surfaces together. The electrical charge that is produced travels when it grows too large for the surface that is carrying it. It travels from cloud to tree, from truck to chain.

Sometimes man needs to keep electricity in a certain place. Instead of using a metal that is a good conductor because it carries electricity easily, man needs to use an insulator to hold back the electricity. Rubber, glass, cloth, and wax are satisfactory insulators, because they do not collect electricity rapidly.

Wires Which Carry Electricity. But frictional electricity on the earth's surface is generally not a great source of danger. It is the electricity that man makes and sends in all directions to work for him that needs controlling. Wires which carry this electricity are carefully insulated.

Notice the electric cords that are used in your home. Those that lead to the lamps from the socket in the wall are covered with rubber and cloth. Those that lead to your bells are covered, too. All the paths for electric current are covered with rubber or fabrics that are poor conductors of electricity. Examine the cord that carries electricity to your toaster, to your father's electric razor, to your brother's electric trains, to an electric heater, and



to the radio. They are all insulated. If the insulation wears off the wire, it is dangerous to use the cord.

Electricity Can Flow through People. Sometimes insulation on a wire or on metal equipment wears out. The white porcelain of which most bathtubs are made is a good insulator; but bathtubs made with a white porcelain coating over metal are dangerous when the layers of insulation have worn thin. Even new metal bathtubs may not have a layer of porcelain on them thick enough to keep house current from traveling through them.

The human body is a rather good conductor of electricity, too. If, while standing on a good conductor of electricity, a person should touch a wire that is carrying electricity, electricity may flow through him.

Electricity can travel from a poorly insulated light switch, through you, through the tub, and down the water pipes to the ground. Therefore it is dangerous to put one hand on a switch and the other on a faucet.

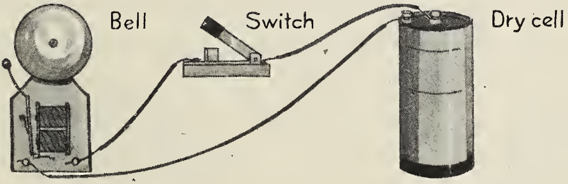
Wet hands make better conductors than dry ones. When electricity travels through your body, it may cause a serious shock. It might cause severe burns or even kill you. So be careful to stay away from electrical outlets when you have wet hands or when you are touching water pipes, so that you will not be a path for electric current.

Special Paths for Electricity

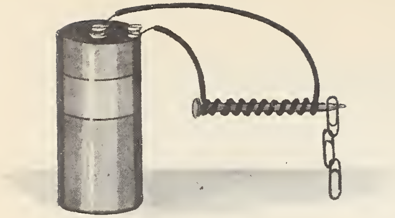
Insulated wires are paths that man has made to send electricity anywhere he wishes to send it. Current electricity, which is sent over wires, is made from chemicals in dry cells or storage batteries, or from electromagnets such as are used in power plants.

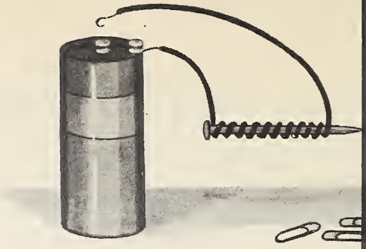
Electricity Flows through a Doorbell. Have you ever made a path for current electricity by connecting a doorbell to a dry cell? Electricity will flow from the dry cell to the bell and back to the dry cell in a complete circuit. A switch placed in the circuit will interrupt the electricity as it travels over this path.

Even though you cannot see electricity, you can follow its path through the inside of a bell. You can learn how to control electricity so that it will ring the bell. Take off the cover which is screwed to the block of wood. Do you find anything underneath the cover that looks familiar?



The two parts that look like spools of wire are





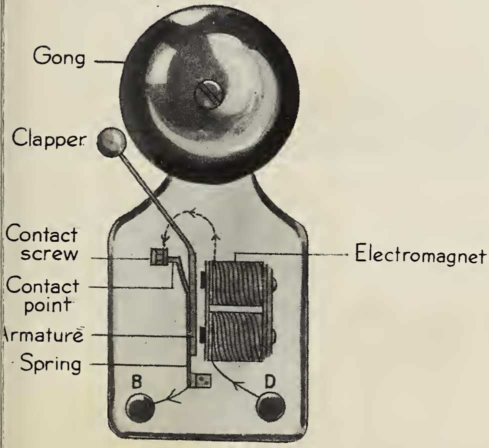
really electromagnets. They are very much like the electromagnets you make when you wrap a wire around a nail. You will find that they work in the same way.

When electricity is flowing through the wire, the nail is an electromagnet. When you take one wire from the dry cell, the circuit is broken. Electricity no longer flows through the wire, and the nail is no longer an electromagnet.

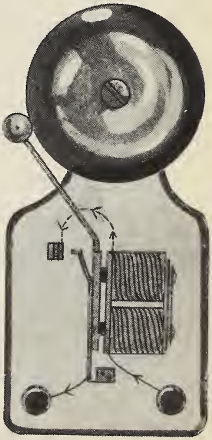
Connect the doorbell to a switch and a dry cell so that you can make electromagnets of the two spools of wire. Watch the piece of metal near them as you close and open the switch. Can you see the iron bar move to the electromagnet? Quicker than a wink, this metal arm, which is called an armature, moves over to the magnet. The clapper which hits the gong goes along with the metal arm. And along goes another little piece of metal called a contact point.

In the left-hand picture of the bell on the opposite page, a contact point is shown touching another small piece of metal, the contact screw. In this way the electricity flows from one piece of metal to the other. In the picture at the right the moving part, called the armature, has pulled the contact point with it. Now there is a space between it and the contact screw on the bell. Electricity cannot travel back to the dry cell, because the circuit is broken.

The electromagnet does not pull on the metal arm, or armature, when the circuit is broken, for it is a magnet only when electricity is flowing through it. A spring at the bottom of the moving arm pulls it back to its original place. Now the contact point and contact screw touch again, and electricity flows through the circuit. The electromagnet attracts the armature again; so the armature moves over and takes the clapper with it. The bell rings again. But when the armature moves to the electromagnet, what happens to the contact point on it? Since the circuit



Current flows from D to B

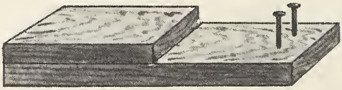


breaks again, the spring pulls the armature back. The same thing happens again and again.

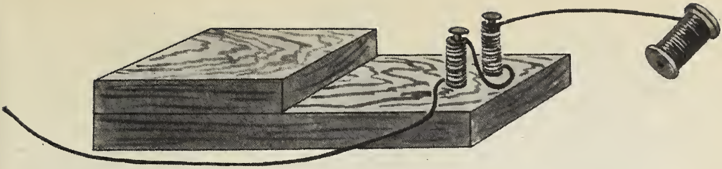
It takes much more time to read about what happens than it does for the bell to ring. The circuit is opened and closed at the contact point so rapidly that it is difficult to see what is happening. Instead of hearing each separate sound made by the clapper, you hear a buzz. The clapper taps so rapidly that the sound is continuous.

How We Telegraph. Would you like to make a telegraph set? You can send messages from one room to another by interrupting the path of electricity as it travels through wires.

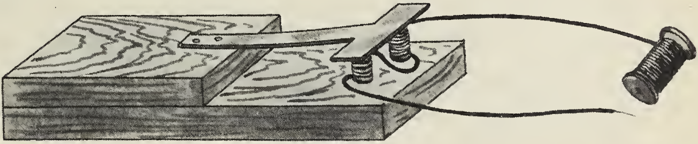
Fasten two blocks of wood together, as in the picture. Then put two large nails near the end of the large block of wood. Drive them into the wood far enough to make them firm. The nails will be the electromagnets in your telegraph set.



Hold a spool of insulated magnet wire about two feet from the end of the wooden block and neatly wrap the wire clockwise from the bottom to the top of one nail. Make as many turns of wire on the nail as you can. Then take the wire across to the other



nail. Wind this nail from the bottom to the top counterclockwise, making as many turns on it as you can. Unwind the wire still more before you cut it from the spool.



Cut a T-shaped piece of metal from a tin can so that it will fit over the nails, like the piece in the picture above. Fasten the metal piece to the top block of wood and bend it until it is just above the nails.

Would you expect electromagnets to attract tin? The metal in a tin can is really iron that has been coated with tin. The magnets will attract the iron under the coating.

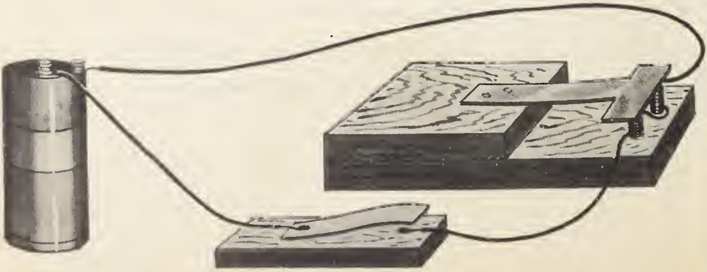
Remove enough of the insulation from the wires at the end to connect them to a dry cell. Now watch the nails to see if they act like electromagnets. Do you hear a click as the metal strip strikes them? If the metal strip does not strike the nails, adjust it until it is nearer the top of them. This part of a telegraph set is called a sounder, because it makes sounds. The next time you enter the telegraph office listen to the busy sounder.

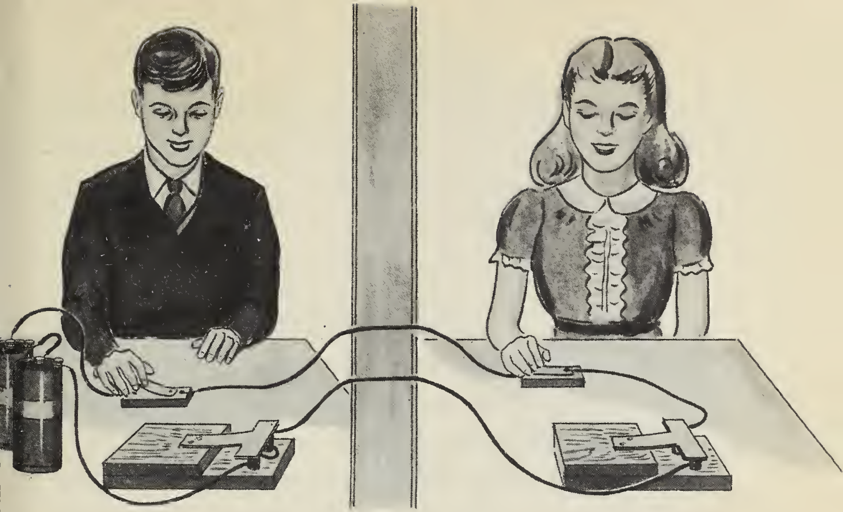
When you disconnect the wires, the circuit is broken. The electromagnets no longer attract the piece of iron. Does the metal strip of the sounder rise when you take one wire away from the dry cell?

A key, or switch, makes it easier to open and close the circuit. Perhaps you can make a key for your telegraph set like the one in the picture. You can use strips of metal from a tin can for this too. Wrap the end of one wire from your sounder around a round-headed wooden screw. Drive the screw into a 3-inch wood block.

Now scrape the insulation from the end of another piece of wire, and wrap the wire around a screw before you fasten the 2-inch metal piece with this screw. Then connect your telegraph set in the way that the one in the picture below is connected.

If you wish to send a message, you must press your key down and quickly release it. This causes a click. A very short pause between clicks is called a dot. Longer periods of time between clicks are called dashes. Dots and dashes stand for the various letters





of the alphabet. When we send telegrams, our messages are sent as dots and dashes.

If you wish to send messages between two rooms, you will need two telegraph sets. You must hold down the key of your set when you are receiving a message. Your sounder cannot tap out the message if the circuit is broken by an open key. You may need to use several dry cells if you want to make electricity travel a long way.

Commercial telegraph sets do not look like homemade ones, but they work in a similar way. Sometimes operators in telegraph offices receive and send their messages on machines that look like typewriters.

Telegraph wires stretch from city to city. Over them travels the electricity which makes similar machines type out messages on a tape. In this way electricity works for us in sending messages to almost every community in the country.

Heat from Electricity

Electricity can be changed to heat by making it travel through wire. In its path through bulbs, irons, toasters, and heaters, electricity travels in coils of wire where it becomes heat.

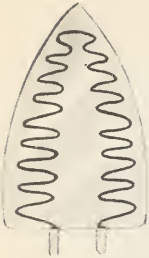
White-hot wires light our houses. Electricity travels through miles of wires to heat the very thin wire in our light bulbs white-hot. The wire is hotter than the wire in a red-hot toaster, for the wire in the light bulb is thinner. Wire in the bulb will resist the flow of electricity even more than the wire in irons and percolators. The wires glow with enough heat to furnish us with light.

Scrape the insulation from the ends of two pieces of copper wire that are covered with cotton insulation. Carefully connect the two ends of the wire to a dry cell. As soon as the wires are connected, electricity will flow through the cell, and some of the electricity will be changed to heat. Be careful not to touch the uninsulated part, for it may be very hot; but place a finger on the insulation to feel the heat produced by the electricity as it flows through the wire. As soon

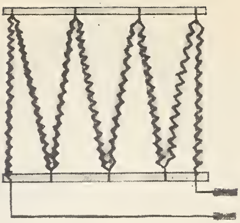
as you have completed this experiment, disconnect the wire.

Certain kinds of wire permit the flow of electricity more easily than others. Copper wire and silver wire are good conductors of electricity. Even though silver wire is an easier path for electricty than copper, it is not used so often. Can you tell why?

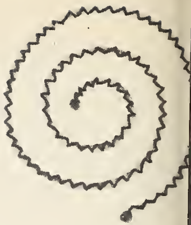
Insulated electric wires make easy paths for the electricity that must travel to the electrical equipment in our homes. These wires are made so that they will not hold back the electricity before it reaches the coils that are to be heated. When electricity reaches the coils of wire in an iron, the iron is made hot enough to press or to iron our clothing.



Iron



Toaster



Stove

Have you an electric heater? Look at the coils of wire inside of it. They are made of wires that are smaller than those that carry electricity to the heater.

There is thin wire in a toaster too. This wire is made of a metal that will hold back the flow of electricity more than copper wire will. Often nichrome is used for wiring a toaster. It is a combination of nickel and chromium, from which it gets its name. Since it is sixty times as hard for electricity to flow through thin nichrome wire as it is for it to travel over copper wire, the wire in the toaster grows hot enough to toast your bread.

Electricity works for us when it heats our food on an electric stove. Waffle irons, heating pads, and electric grills also use heat from electricity.

Light from Electricity

Light Bulbs Glow with Heat. The wire in a light bulb is made of metal that has been stretched until it is finer than the finest hair. When the button is pressed, the wire begins to glow from the heat. Do you know if it was easy to find a wire that would stretch until it was very thin and also stand enough heat to furnish the light needed in a light bulb? Most metals melt before they become hot enough to glow with a white light. Most materials that are very thin melt or burn up very quickly.

The First Light Bulb. Many scientists experimented to find a substance that would not melt when it became white-hot. Thomas Edison worked patiently, testing one material after another. He and his helpers tried every kind that they thought might be used. They even tested a hair from one of the men's beards. They found some substances that did not melt right away from the heat, but they would burn up in a short while. After they had burned or melted, no more light came from the bulb.

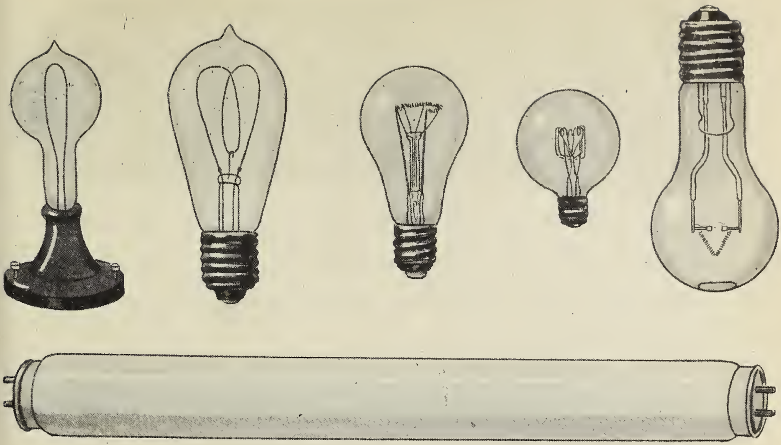
Then scientists learned to take most of the air out of the light bulbs. Less oxygen kept the materials from burning fast, but it did not keep the heat from melting the materials.

After many failures, Edison gained hope from the glow made by a thin thread of black carbon. You can make a carbon thread somewhat like the one Edison used. Ask your mother if you may put a piece of cotton from a spool of heavy white sewing thread in the oven when she is baking. It will change from white to black, because the cotton is changed by heat so that only carbon is left. You will find the carbon thread difficult to handle because it will break easily. If you rub it between your fingers, it will fall apart and leave tiny bits of carbon on your hands.

Edison baked a piece of cotton five hours. When he first tried to pick up the carbon threads, they broke. He tried time after time before he was able to seal a thread in a light bulb. For two days and two nights Edison worked. At last the carbon thread was fastened in the bulb and the current was turned on gently. Think how anxious he must have been to know if his experiment would be successful. The lamp gave off a soft glow. Edison watched it for forty-five hours while it continued to give off light.

Modern Light Bulbs. Edison and his helpers kept on experimenting in order to improve the light bulb. Even today people are working to improve it.

The wire in most of the light bulbs used today is made of tungsten. Tungsten ore is found in the United States, in China, and in Burma. The tungsten is spun so fine that a pound of it will make a wire 450 miles long. This fine tough wire



can stay white-hot for a thousand hours before it will break.

Perhaps you have heard the tungsten wire rattle in a worn-out bulb. Look at the wire in a broken bulb and trace the path the electricity would take. The coil in some bulbs is double, but the wire is so fine that one can hardly see that there are two.

"Cold" Lights. Nowadays still another kind of electric lighting is being used. When electricity flows through certain gases instead of through metal wire, light is produced with much less heat. The bright orange-red light which is produced when electricity flows through neon is used in making the electrical

signs that are used for advertising. Sodium vapor lights which give off a yellow light are used along highways and at airports because this kind of light is visible through fog.

Fluorescent lights are used on many signboards, in a great number of offices, and sometimes in modern homes. Electricity traveling in these long, narrow tubes of gas produces rays which we cannot see. When these rays fall on a special kind of paint inside the tubes, light is produced.

These "cold" lights use less electricity than the older tungsten filament lamps. Just as the tungsten bulbs took the place of the old-fashioned yellow carbon bulbs, so cold lights may someday take the place of the tungsten lights we generally use today.

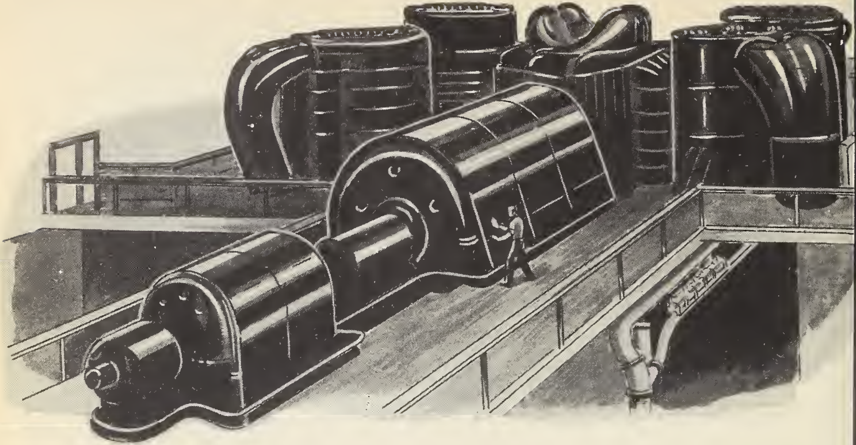
Electricity Works as It Travels

It is difficult indeed to imagine living through a day without the current electricity that is produced in the power plant miles away from you. Think how electricity has helped you today. An electric alarm clock may have waked you. An electric toaster made your bread more tasty at breakfast. The milk and butter came out of a refrigerator that required current electricity to keep it operating. The heat in your new furnace may be controlled by electricity, which came into your house on rather thin wires. The waffle iron, the washing machine, the radio, the vacuum cleaner, and finally the lights of evening—all have used electricity.

As we use it at home, so also factories and places of entertainment demand much of this great servant of man. Motion pictures, streetcars, electric railroads, machines in practically every factory of the land—all call for this form of energy. Many farmers use electricity to run their pumps, operate their milkers, cut their wood, or do other tasks that used to be done by many hired men.

But It Is Not Frictional Electricity

We have traveled far away from the electricity that we made by rubbing our shoes against the parlor



rug. The great servant of man is not produced in such a simple way. In fact most of the current electricity that travels around the country is made by machines that are turned by water power or the power of burning coal. Moving coils of wire near great moving magnets produce enormous quantities of electricity. Electricity may be made by different means, but the effects it produces are all the same. Through the use of electricity man's work is done faster and more easily than ever before.

MORE THINGS TO DO

1. In one year electricity gave us the power of one billion strong men working eight hours every day for a year. Make a list of all the ways in which electricity has helped you today.

2. Write a story about how different your life would be if men had not learned how to send electricity through wires.

3. Take a walk to look for lightning rods on the buildings in your neighborhood.

4. Ask the man who is in charge of the lights in your school to tell you how electricity enters the building and travels to the bulbs in your classroom.

WHAT DO YOU THINK?

1. Make a list of insulators and another of conductors of electricity. Can some materials be in both lists? Explain your answer.

2. Why is electricity a fast messenger?

3. No one has ever seen electricity. How do you know that it exists? Give as many reasons as you can.

4. In flour mills a tiny spark may cause the dust in the air to explode. What do you think might cause such a spark?

5. Tell why copper wire is not used in light bulbs.

Travel by Air

Men with Wings

Long ago men thought that they might be able to fly like the birds if only they had wings. So they tied large feathered wings to their arms, and flapped them. But their muscles proved too weak to support flapping wings that might carry them through the air.

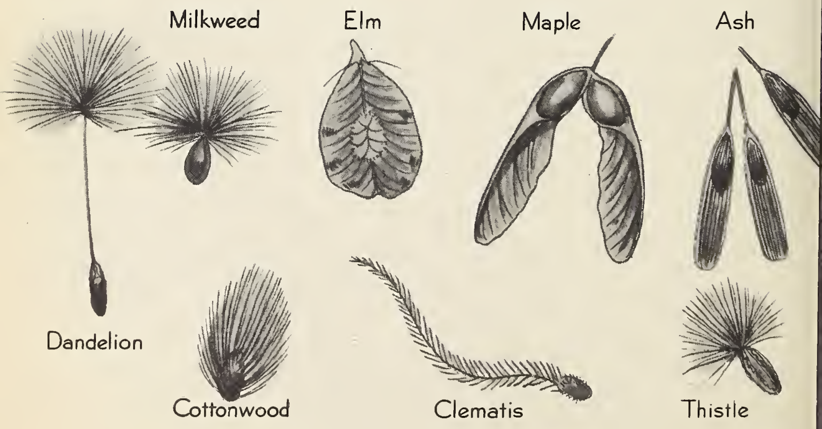
Leonardo da Vinci, the great Italian painter who lived about five hundred years ago, dreamed about flying in the air. He filled notebooks with ideas about flying machines. He watched birds, and he pictured machines with flapping wings. But he did not learn how to fly.

In 1675 a Frenchman named Besnier fastened flapping wings to his shoulders and jumped from a barn loft. He sailed over the roof of a cottage and drifted to earth several hundred yards away. Even though Besnier was not hurt, as his neighbors thought he surely would be, his flight was not very successful.

Man is not the only living thing that is unable to fly. Most plants and a great many animals cannot travel in the air. By studying the plants, insects, and birds that can fly, however, scientists have been helped in working out ways for people to fly.

Plants That Float through the Air

Some plants are air travelers during part of their lives. Seeds may be scattered for miles and miles by wind. Have you ever blown the seeds of a dandelion and watched them as they fly through the air? Milkweed seeds float around in much the same way, because they too have little silken hairs attached to them that help them to fly. Notice how many little silken hairs are fastened to one seed. Compare their length with the size of the seed.



There are other plants that have their own parachutes. Clematis seeds are carried through the air by a long curly wing. Cattail seeds, cottonwood seeds, and the many seeds found in each sycamore burr have their own silken down, which helps them to float through the air.

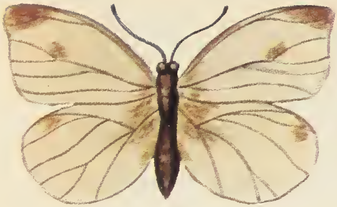
Elm and ash seeds are carried above the ground by other kinds of wings. The maple-tree fruit whirls like an airplane propeller as it settles to the ground.

Insects Travel in the Air

Most insects are flyers, too. Before insects are full-grown, they crawl or walk along the ground or they swim in the water. But when their wings are developed, many kinds of insects can travel in the air.

Perhaps you can catch some insects, so that you can study them. A slice of fruit on a saucer might attract them. Insects may collect on a piece of raw meat which has been left uncovered in a warm place. Look for insects in gardens and in the woods. Sugar will attract flies and ants.

There are probably about a million different kinds of insects in the world, but only a few kinds have no wings. Silverfish, which sometimes dart about dark closets, cannot fly. Bedbugs do not have



Insect with wings
Cabbage butterfly

Insect without wings
Cat or dog flea

wings; they crawl from one place to another. Fleas must hop about, since they have no true wings. The queen ant loses her wings after she has used them for her wedding flight. She cannot fly again. Most other ants cannot leave the ground.

Insect Wings. Most insects have two pairs of wings. When an insect is not flying, one pair of wings is usually folded beneath the other.

Perhaps you have noticed the hard outer wings of a beetle. A beetle holds them still when it flies, and they look somewhat like airplane wings. At other times these wings protect the pair of thin wings beneath them.

Insect wings are of various shapes, but most of them are triangular. The leathery wings of a grasshopper are not very much like the soft, delicate wings of a butterfly, which are covered with tiny scales. Some insect wings are very colorful and beautiful.

Have you ever watched a dragonfly? This insect frightens people who do not know anything about it. Dragonflies look rather fierce as they dart about in search of food. These flying dragons never fold their large, gauzy wings, not even when they are resting.

Hard ridges, called veins, make an insect's wings stronger. Try to see these veins when you next look at the wings of an insect. Look for them in the picture of the dragonfly. Different kinds of insects have veins arranged in different ways. These marks help scientists to decide what kind of insect they are examining.

How Insects Fly. When an insect flies, its two pairs of wings work together. They often lock together in flight. By moving the strong flight muscles in their bodies, insects can flap their wings up and down very rapidly. For example, a housefly can move its wings up and down more than three hundred times in a second. The wings move so fast that you can scarcely see them.

Even though their wings move rapidly, most insects do not travel very fast. Those that fly 30 miles an hour are among the fastest. But some insects can fly so high that aviators have found them more than two miles above ground.

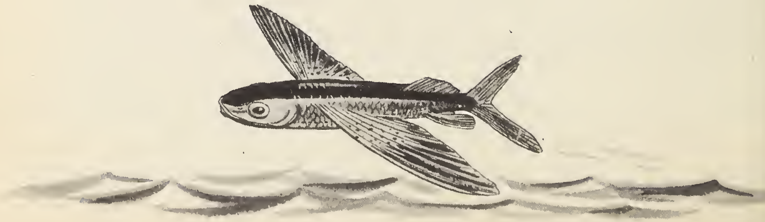
Insects can fly high rapidly because their body weight is light and their wings are large for the size of their bodies.

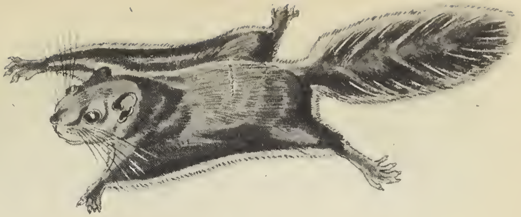
Flying Fish

About seventy-five different kinds of fish can leave the water and travel short distances in the air. Most of these are very small fish that are found in warm waters.

A flying fish goes into the air above the water to get away from its enemies or to catch food. Before it leaves the water, it waves its tail back and forth to gain speed. Some fish reach a speed of 10 yards a second. A champion runner cannot run much faster than this. When the fish has gained enough speed, it lifts itself out of the water. Then it spreads its fins and holds them straight out like airplane wings.

Flying fish stay in the air as long as they can go forward. As they lose speed, they gradually sink and return to the water. But they sometimes glide a distance of 50 yards. Imagine a fish gliding above the water 150 feet! Do you think its enemies have much chance to catch it?





Flying Squirrels and Bats

Certain kinds of squirrels in the woods of North America also avoid their enemies by gliding. They travel at night, for they are able to see rather well in the dark, and it is safer then.

The flying squirrel looks much like other squirrels except that a piece of skin on each side of its body is stretched between the front and back legs as far down as the lower joints. You can see this stretched skin in the picture above. As it leaves a tree the squirrel spreads its four legs, and these pieces of skin serve as wings. Its broad flat tail helps to guide its flight. The distance a flying squirrel travels depends on the height of the tree from which it starts. For squirrels do not really fly. They glide forward and downward; then they run to the top of the next tree to glide again.

Bats are able to travel through the air for a much longer time than squirrels can. They depend almost entirely on their wings to get from place to place. From the four long fingers on the front limb, the wing of a bat stretches back to its hind leg. Here it is fastened so that the back toes are free.

Bats fly quickly, and often dart about in many directions. Most of them fly at night to feed on insects, which they catch in the air. Bats fly in this strange way because they are chasing insects, not because they are blind.

Can All Birds Fly?

Some birds cannot fly. Perhaps you have seen an ostrich at the zoo. It takes large steps with its long legs. An ostrich's wings are small compared with the rest of its body and cannot lift it from the ground. A grown ostrich can run very fast, even though it weighs about 300 pounds. When it runs, it spreads these small wings so that they act as sails.

Look at the wings of the penguin in the picture. Would you expect these birds to fly? Their wings are used for swimming through the water instead of for flying through the air. Penguins have no flight feathers. Their short, stubby flappers, which serve as paddles to push them forward through the water, are covered with scalelike feathers. Short, stout legs carry penguins over the ground clumsily. When penguins get tired, they flop on their stomachs and paddle along in the snow or mud. Penguins' wings help them to travel in the water and over the ground, but they do not carry them into the air. How else is the penquin equipped to help it move through the water?

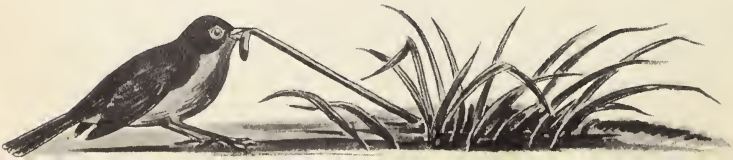
Why do you suppose a certain kind of low-powered airplane, which is used only in aviation training schools, is called a penguin?

Explorers have seen fifteen kinds of penguins. Some are only about 17 inches high, or only 5 inches taller than your ruler. Other penguins are taller than your yardstick and weigh more than 80 pounds. But no matter how large or small a penguin is, it cannot fly. How is the penguin well equipped to live in the Far North?

Most Birds Are Built for Flight. When men tied wings to their arms, they could not fly much better than an ostrich or a penguin. The wings were not large enough to lift their heavy bodies into the air, and their arm muscles were not strong enough to move larger wings.

Most birds have bodies that are light and small enough for wings to carry them through the air. Many of the bones in their skeletons are hollow. This makes them light, but still they are strong. Birds have strong shoulder bones which support their wings. Their breastbones and breast muscles are powerful and built for flying. The white breast meat is the muscle which is attached to the chicken's wing. The next time you have chicken for dinner, notice the position of the white meat. Collect the bones before they are thrown away and notice that they are light and spongy. You can see how bones like these can be carried through the air more easily than thicker, heavier ones.

A great amount of energy is used in flying. Remember that food is needed for energy. The food a bird eats daily may weigh more than the bird itself. Scientists have watched birds to see how much they eat. They have found that one young robin, just after it has left its nest, will eat as much as 14 feet of earthworms during a day. It is not a very



large bird, but it needs a large amount of energy for flying.

A bird's wings take the place of front arms or legs. The bones in the wing are put together so that a wing can fold into a Z shape. But when a bird flies, its wings are stiff and straight like the wings of an airplane. Spread out, they cover a surface much larger than the bird's body.

The feathers that cover a bird's wings help it to fly. If you can, collect some feathers from a barnyard or from an old hat. Look for the hollow tube in the center of the wing and for the many fine branches on a feather. A reading glass will help you to see that each little branch is really a feather hooked into another feather like a zipper.

When you lift a feather, it seems to have no weight. Because the feathers overlap, however, the wing can press against the air when it is flapped.

Sometimes Birds Are Gliders. With motionless wings, birds glide through the air somewhat like

Gulls gliding
Gulls soaring on rising air currents

flying fish and flying squirrels. Whenever these animals glide, they fall slowly through the air until they reach the ground or the water. A gliding bird sinks toward the earth, unless it travels in a rising air current. Then the bird is carried up by the air.

Perhaps you can imagine how birds glide. Pretend you are traveling on a large ship. A sea gull is gliding near by with wings outstretched and still. The gull floats lazily through the air, gradually sinking toward the water. Suddenly a strong breeze blows against the side of the ship. The air is forced up, and the gull is carried along with the wind. It rises as the upward moving air pushes on the underside of its wings.

Air currents are moving all over the earth. Some are large; some are small. Hawks, gulls, and many other birds find these rising air currents, which carry them sailing through the air on motionless wings. Sometimes these "hitchhikers" in the sky are called soaring birds, because they sail along for long distances by gliding down and soaring up.

Watch birds as they fly. Have you seen a bird glide through the air? Watch for a bird traveling without moving its wings.

Birds Need Energy to Fly. Most bird flight depends on flapping wings. The motion of the wings lifts the bird into the air. The wings push the air back, thus moving the bird forward. Sparrows flap their wings about 13 times a second. Such exercise requires much energy. No wonder birds eat so much! They need a large amount of food to supply the energy they use while flying.

Pigeon's wings make about 8 strokes in a second. Larger birds usually do not flap their wings as fast as smaller birds. Would you expect a hummingbird's wings to move rapidly? Sometimes they make as many as 200 strokes a second.

Gulls flying

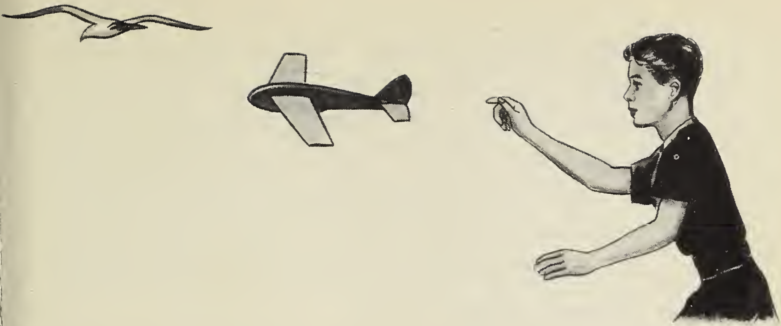
Can you move your pencil as fast as a hummingbird moves its wings? If you have a watch with a second hand, you can try this experiment. Have someone time you while you see how many marks you can make in five seconds. Write as fast as you can and make as many dots as possible. Divide the number by five to get the average for one second.

Of course not all birds move their wings as fast as hummingbirds. But a bird must move in order to stay in the air. Sometimes birds move with still wings, because the wind carries them, and sometimes they fly by moving their wings through the air. Either moving air or moving wings keep the bird in the air.

Men found long ago that they could not fly like birds simply by fastening wings to their arms, but that did not stop them from trying to fly. They continued to try to imitate the birds. But men's bodies are not built at all like the body of a bird. Finally, men found another way to fly. They built planes that can fly faster and farther than birds.

Planes That Glide Like Birds

Perhaps you can bring some models of planes to school, so that your class can watch them as they glide through the air. See if they remind you of a bird with still wings.



Many models of planes can travel in much the same way as the gliders that carry people through the air. Gliders are airplanes without motors. They are like birds that glide with still wings. Unless the model has a motor to carry it through the air, it will act like a glider.

Have you experimented with model planes on a windy day? When moving air pushes under the wings, the model of the plane or the glider rises.

On a still day a glider will stay in the air only a short time. Can you tell why? The light body and the large wings of a glider keep it from falling quickly to the ground. It coasts along, dropping bit by bit, unless it is caught in a rising air current which carries it ahead. When air is not moving past the wings of a plane, the plane sinks to the ground.

The spread wings of a gliding bird and the wings of a glider are very much alike.

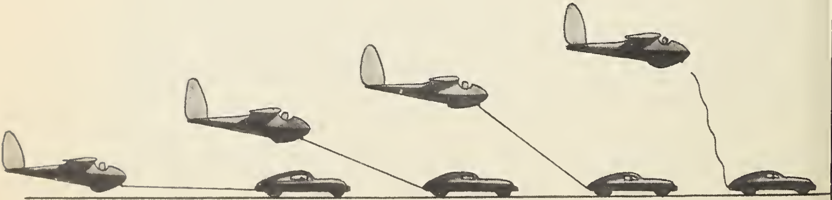
Getting Off the Ground. Before a bird can glide through the air, it must flap its wings to get above the ground or must start from a high place such as a cliff or a mountaintop. It must have a flying start.

Do you lift your model plane as high as you can before you send it on its way? When model planes are sent through the air, they begin their journey from high above the ground.

Large gliders must be moving before they can be picked up by air currents. Air currents alone do not pick them off the ground to start them on their journey.

When pilots talk about getting a glider into the air, they say they are launching it. A pilot can start a glider from a hillside or a cliff. His helpers pull the glider along until it is traveling at the right speed. As it gains speed, wind gets under its wings, and rising air currents carry the glider upward.

But the pilot does not need to start from a high place to take a ride in a glider. He can fasten his plane to an automobile by a towrope, and then have a helper drive the automobile across the field. As the car gains speed, the glider gradually goes into

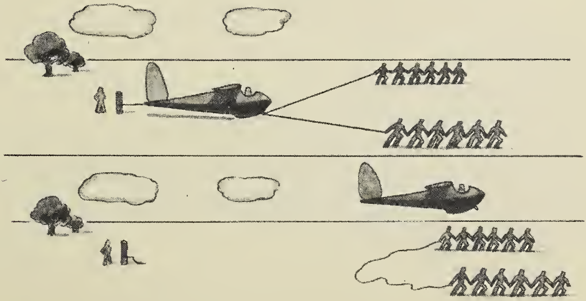


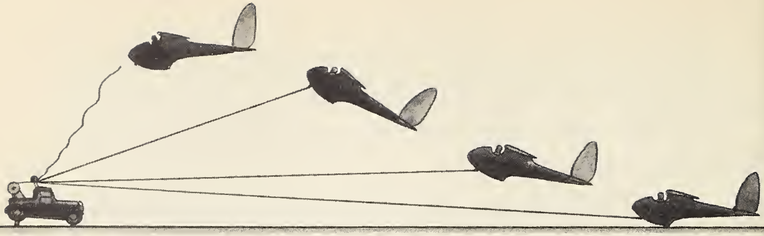
the air the way a kite rises when you run into the wind with it. When the glider is high in the air, the pilot no longer needs the towrope; so he throws it out of the plane.

Sometimes gliders are pulled into the air behind a plane that has a motor. Several gliders can be launched at one time by a single airplane.

There are still other ways of launching gliders. Imagine a glider in a large slingshot. The glider is anchored to a post, and many men are pulling the rubber cord. Then the glider is released from the anchor. It springs forward with such speed that it goes on its way into the air.

Perhaps you can launch a model plane by putting it in a slingshot. Hold the forked stick in one hand





and hold the plane inside the rubber bands as you stretch them with your other hand. Release them, and off goes your plane.

Another way to launch a glider is to use a machine which has a reel much like the reel of a fishing rod. A motor turns the reel so fast that the glider is pulled forward as the towrope winds around the reel. When the glider reaches flying speed, the pilot casts off the towline.

A glider often reaches a speed of 40 miles an hour before the towrope is released. Sometimes a glider reaches a height of 800 feet before it is freed from the automobile or plane that is towing it.

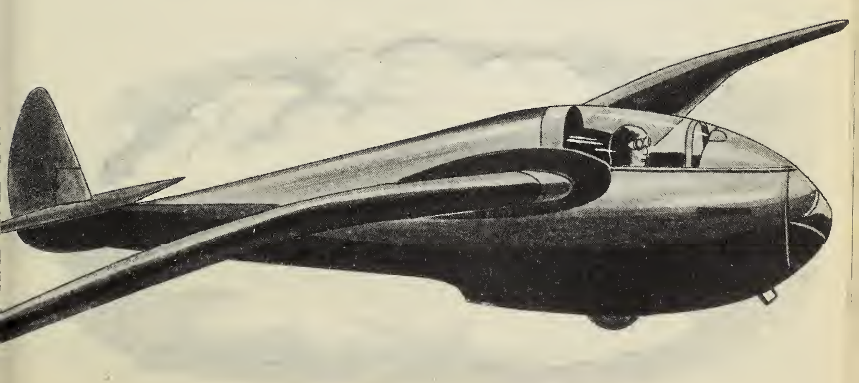
How Far Can a Glider Travel? Some large gliders are so carefully made that they can sail through the air a distance of 500 miles. They are as expensive to make as are some other kinds of planes. These soaring gliders, called sailplanes, have graceful lines and are light for their size. Their large wings are so strong that high winds will not tear them apart.

Notice the graceful lines and the wings of the sailplane in the picture below.

Sometimes men have glider races to see which one can stay in the air the longest time. Some gliders have traveled almost 500 miles without the help of an engine. Some sailplanes have been in the air as long as 50 hours. Others have climbed high into the air. Glider pilots have reached a height more than three miles above ground.

The speed of a sailplane is not as great as that of an airplane with a motor, for a sailplane's average speed is only 40 miles per hour. Flying on rising air currents is an exciting sport, but it is not the best way to travel. Wouldn't it be inconvenient to have to wait for the proper air currents every time you wanted to take a trip in a plane? It would be like the old sailing days, when ships had to wait for the winds to blow them across the seas.

When a glider is towed by a plane with an engine, it can be led to the place where the pilot wants to



take it. When another plane pulls a glider forward, it does not have to depend on winds to keep it from sinking to the ground. Towed gliders carry freight across the oceans. Sometimes large numbers of people travel in a glider which is being towed.

Airplanes with Motors

When birds glide, they sink to the ground in much the way that gliders do. When air currents do not move the glider forward, it begins to sink. But birds can stay in the air by using their own energy to flap their wings up and down.

Can you imagine an airplane with wings that flap up and down like a bird's? It would be difficult to raise and lower the wings of an airplane fast enough to make it move ahead. Instead planes are usually moved through the air by a whirling propeller. Engines make the propeller move rapidly. Gasoline supplies the energy to turn the propeller, just as food provides birds with energy to fly.

Have you ever looked carefully at a propeller?

A propeller is made of curved blades somewhat like those of an electric fan. As an airplane propeller spins around, the curved blades bite into the air in front of the plane and this pulls the plane along. These blades push the air backward so forcefully that the plane is driven forward.

The propeller of a plane serves the plane in much the same way that wings serve a bird. Now let us see how a plane gets into the air.

How Planes Get into the Air. Perhaps you have noticed how a plane runs along the ground for quite a distance to gain speed. Like gliders, planes with motors must be moving in order to get into the air.

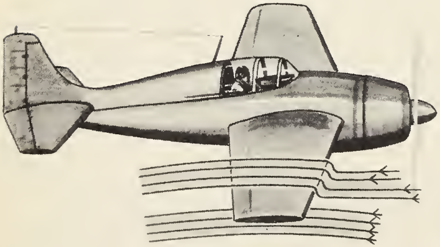
A pilot climbs into his plane. He turns on the motor. Whirr! goes the propeller. The engine warms up, and the plane rolls along the ground. The pilot adjusts the controls and pulls back on the stick. He is off! The plane goes into the air and flies through the sky. What has happened?

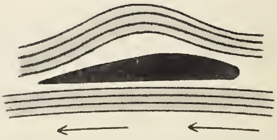
In the first chapter of this book you were introduced to the molecules. Here they are again. There are billions of air molecules. When you run, many of these molecules are bumping against you every step of the way. They push against you. They are "the wind."

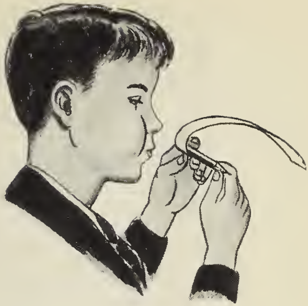
A kite is pushed in the same way; and you, on the other end of the string, feel the pressure of the air molecules on the lower side of the kite. Moving air is composed of pushing molecules. When the molecules stop pushing, the kite falls. If that begins to happen, you, who have hold of the other end of the string, will run over the field to produce wind.

So a plane goes up and stays up. If it travels along the ground fast enough, more and more molecules bump against the underside of the wings. When the push is strong enough, it will lift the plane from the ground. Someone may wonder whether molecules push against the top side of the wing too, and why that would not balance the upward push. It would; but men make airplane wings of a special shape.

The air traveling across the curved upper surface of the wing of a plane has to travel a longer distance than the air below. The push of the air on the underside of the wing is greater than the push against the upper side.







You can do an experiment to show that moving air will lift a curved surface as it flows by it. Cut a piece of paper one by six inches and hold it over a pencil. Hold the paper at the level of your mouth. Now blow. Do you see the paper rising?

The wings of planes with motors are shaped somewhat like the wings of gliders. They are curved so that air can travel a longer distance across the top than across the under surface of the wing. This causes less push on the wing from above than from below. The harder push on the under surface of the wing helps to keep the glider up. But gliders have no motors to turn propellers that can pull them forward. Now you can understand why gliders are not as useful for travel as planes with motors.

Testing New Wings. New wings of airplanes must be carefully tested to see if they are satisfactory. A wing is placed in a large tunnel where blasts of air are blown past it. In this wind tunnel the action of the wing can be watched under various conditions. If the wing is shaped properly, it will rise as air is blown across it.

The air in a wind tunnel acts in much the same

way as air that moves across the wings of a glider. Since air is blowing across the wing in a tunnel, no propeller is needed to pull it forward. In wind tunnels air moves over and under the curved wings. It moves over and under the wings of gliders and of planes with motors and helps to keep them in the air.

Sometimes models of planes are tested in wind tunnels. The man in the picture is not catching butterflies in his net. He is waiting to catch the model plane so that it won't crash to the bottom of the tunnel when air stops blowing across its wings.

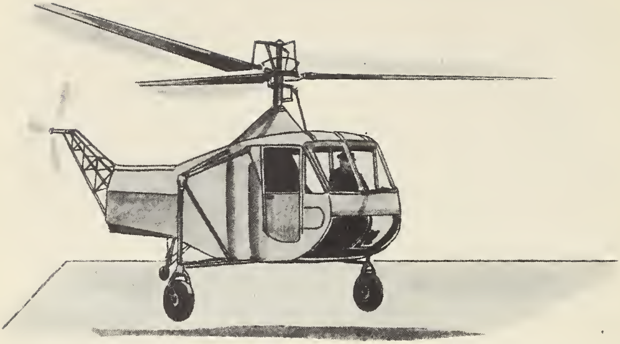
Motion for Flight. Most planes would go down if their wings were not moving through the air. An aviator cannot even slow down very much, because his plane sinks as it loses speed. Automobile drivers are told to travel slowly so that they will be safe.

Quite the opposite is true in aviation. If you become a pilot, you will be told to speed, because it is dangerous to fly slowly.

Do you see why airports must be large? Most planes must gather speed before they can rise into the air. Like gliders, they must be traveling fast, so that enough air will be moving past their wings. Pilots turn their planes into the wind before they leave the ground. Can you tell why?

Seaplanes can use the whole ocean for their airport. Instead of rolling across the ground on wheels, seaplanes travel on the surface of the water for great distances. They can gather great speed before they take off, because they have so much space. That is why some seaplanes hold speed records.

Flying Windmills. A helicopter can take off and land in a very small space. It is a strange-looking airplane, because it has no wings on its sides. Instead it has a special kind of propeller that sticks up above the body of the plane. This propeller is called a rotor. It has large curved blades that serve in the place of wings. They whirl around horizontally instead of the way the propellers of other airplanes whirl. They make a curved air current and keep the helicopter up. A helicopter does not have to gain speed before it rises in the air. It can move its rotor, or



wings, without moving along the ground. The engine of a helicopter can turn the rotor fast enough to make the plane rise almost straight up from the earth.

A helicopter does not have to speed through the air to keep air moving across its wings. Such a plane can stay in one place in the air quite a while. As the overhead wings whirl round and round, the air currents are forced to move so that they push harder under the blades than above them. Even when a helicopter is not traveling forward, it can stay in the air.

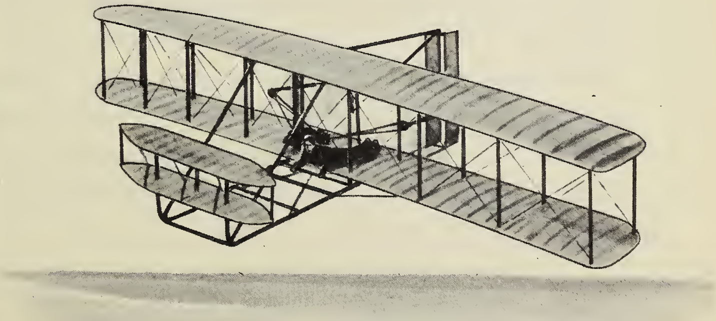
Perhaps if you sometime own a plane of this type you will use your garden or a rooftop as an airport. How handy that will be!

Our First Airplane. How many different kinds of airplanes do you know? Some have wings on top. Some have short, stubby wings on their sides, while others have long, graceful wings. Collect pictures of airplanes and compare their shapes. Perhaps you can find pictures of some that were used before you were born.

Would you like to ride in a plane like the one in the picture below? It is one of the most important planes in history, for it was the very first airplane that was carried through the air by a motor.

Wilbur and Orville Wright, who built it, had a bicycle shop in Dayton, Ohio, where for many years they experimented with gliders in their free time. They studied about gliders and made parts for them. These brothers used all the information they could get from other men who had been gliding in the air.

The Wrights tried their gliders at their camp in Kitty Hawk, North Carolina. Here they had wide open spaces and steady winds to keep their gliders



up. Some of them tipped over and crashed, but the Wright brothers mended them and began again. They wanted to fly a plane with a motor that would turn propellers and at the same time pull the plane through the air.

If you had gone to the Wright brothers' bicycle shop in Dayton, Ohio, on December 17, 1903, you might have seen this sign on the door:

At Kitty Hawk people were watching a great event in history. The morning of December 17 had dawned cold and raw. Puddles were frozen, and a cold wind was blowing from the north. No newspaper reporters had come. Just five people stood in the cold wind on the sandy dunes. They watched and wondered what would happen to the men who were trying to fly a homemade glider with a motor in it.

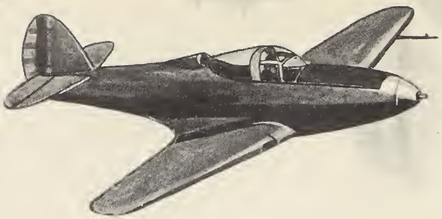
The wings of the plane were made of cloth stretched over a framework of wood. Instead of wheels, runners like those used on sleds were fastened to the plane so that it would slide over a track. Study carefully the picture on page 227 to see how the Wright brothers' plane was made.

The motor was warmed up and Orville Wright took his place on the bottom wing of the plane. He lay flat on his stomach, for there was no place for a pilot to sit. The two propellers whirred, and the controls were adjusted. Then something happened that had never happened before in the history of the world.

Down the track went the airplane. Wilbur Wright ran along beside the plane, holding the wing to steady it. The plane left the ground, dipped in the wind, and rose again. It stayed in the air about 10 seconds. At 10 feet above the ground, the plane flew forward 120 feet. You could throw a stone as far as that. But this flight proved that man could fly through the air with a glider that had an engine in it.

New Shapes for Planes. Now that man could fly, better planes were made. There have been many changes in the engines and in the shapes of planes. Today some airplanes measure more from wing tip to wing tip than the distance first flown by the Wright brothers. Modern airplanes do not look much like the first plane, but the explanation for their flight is much the same.

The old planes had sharp corners which pushed



against the air and held them back. Many men studied ways to make better planes. They watched the graceful flight of birds and noticed their smooth curved lines. Men studied rounded drops of water as they fell through the air, for a drop of water changes shape in such a way that it can travel more rapidly.

They also studied air currents as they flowed around square and rounded objects; for as a plane travels, air flows around it. Because streamlined shapes do not hold back as much air as flat, square ones, corners of planes are rounded. Streamlined trains and automobiles have made it possible for us to travel much faster than we could ten years ago.

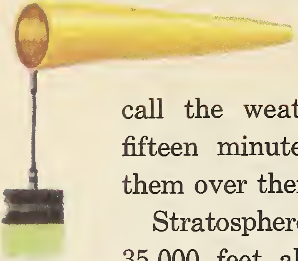
Making Air Travel Safe

Modern airplanes are faster and more powerful than the early airplanes were. They are safer too. Making air travel safe has taken much hard work.

The government protects people who travel by air by requiring men to be well trained before they can hold a pilot's license. And the planes they fly must be safely built and must pass inspection. Beacons warn pilots at night so that they can stay above high towers and mountains. Signals also flash to tell aviators where they are. Have you ever watched the beacons that guide pilots?

Men in radio ground stations control these signals which direct the pilot as he flies. In other ways radio plays an important part in making air travel safe. A pilot can carry on a conversation with the men at the airport by using a two-way radio set. When he is ready to land, he asks the man in the control tower for directions that will help him to put his plane safely on the ground. And radar acts as an electric eye which can see through fogs.

Weather and Safe Flying. Men study the weather carefully, so that they can predict storms and give warnings about fogs and high winds. Many pilots

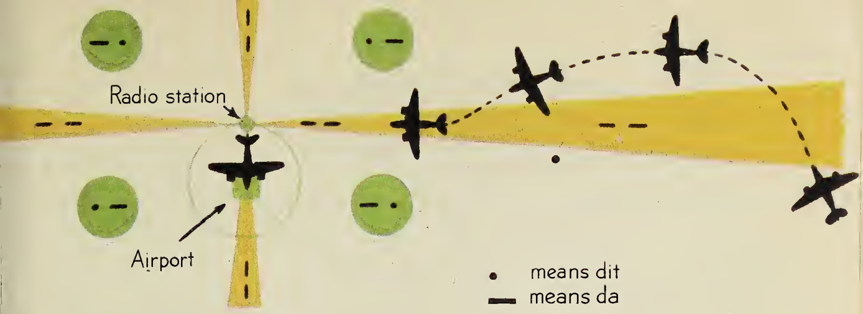


call the weatherman at a near-by airport every fifteen minutes. Reports of sudden storms reach them over their two-way radios.

Stratosphere planes travel above the storms. At 35,000 feet above the ground, air is so thin that there is no weather. Nor is there enough air to breathe. Stratosphere planes must carry air for passengers and pilots. But stratosphere flying is safe. Pilots do not have to worry about storms until it is time for them to land.

Windsocks, which are funnel-shaped, show the direction of the wind at the airport. They are large enough to be seen at a distance. The next time you see a plane land, look for the windsock and watch how the pilot handles his ship to make best use of the wind.

Skyroads. There are well-marked highways in the sky. You cannot see these roads, but pilots can hear them, for they are highways of sound. Radio beams help a pilot to stay within the proper space, or skyroad. A radio beam is not a light; it is an invisible beam which makes a faint humming noise in the pilot's radio set. When a pilot is traveling within a ten-mile-wide path, or skyroad, he hears a noise that sounds like "da." It is a steady hum which gets louder as the plane nears an airport. If a pilot flies too far to the right, he hears "dit da, dit

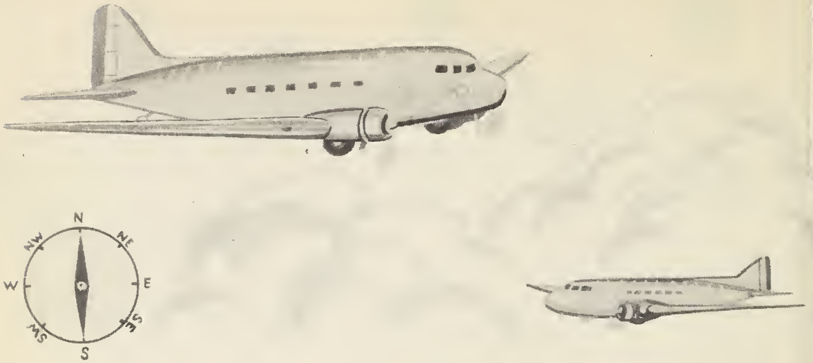


da, dit da," instead of just "da." This warns him to move back into the skyroad where he hears the "da" continuously.

When a pilot turns off the path toward the left he hears a different noise. This time it is "da dit, da dit, da dit." He must fly to the right again until he is back in the safe path marked out by the radio beam. As long as a steady "da" is singing in a pilot's ear, he knows that he is traveling over a safe skyroad.

In some planes lights blink on and off to show pilots whether or not they are staying "on the beam." Many pilots prefer the lights, because they get tired of listening to the steady humming noise.

Air traffic is often very heavy, and planes travel at very fast speeds; so there must be traffic rules in the air as well as on the ground. There are one-way air lanes in which planes must fly. Skyroads are one-way streets in the air. If a pilot is flying west or south, he climbs to an altitude which begins with an even number, for example, 2000, 4000, or 6000



feet. Planes traveling north or east would fly above or below these air lanes. A northbound plane would travel at 3000 feet or at 5000 feet, but it would not travel at 4000 feet above the ground.

Skyroads are mapped, and pilots are warned about crossroads on air highways. Sometimes pilots are given directions to climb 500 feet before they reach a crossing on a skyroad. A northbound and an eastbound plane cannot meet in the air if one flies above the other.

The companies which send large planes from city to city and from country to country choose the safest skyroads. They are proud of their safety records. Air travel today is comfortable, fast, and safe.

Man has learned to fly, not by lucky guesses and chance happenings but by long study, many experiments, and repeated checking and rechecking of many, many ideas.

WHAT DO YOU THINK?

1. Not all moving things can travel in the air. Fast-moving automobiles and trains cannot leave the ground. Can you tell why?

2. Why do people say that airplanes have made our world a smaller place?

3. Do you think that the Wright brothers were lucky? One story states that the Wright brothers happened on the idea of flying by noticing a twisted box. Do you think that is a likely explanation for their great discovery?

4. When birds are about to fly do they face the wind or turn their tails into it? Explain.

MORE THINGS TO DO

1. Watch animals as they travel in the air. Compare them with an airplane.

2. Tell how different kinds of planes are being used.

3. Ask a pilot to tell you how he learned to fly.

4. Describe an imaginary trip in a glider.

Useful Facts about Light

Sources of Light

Beacons of electric light stationed at certain points guide air pilots as they fly at night across the country. These signals help the pilot to make a safe landing just as the light in the window of your home or the electric light on the street corner guides you in going about safely after dark. Those of you who live in the country may use a flashlight to guide you on your path whenever you go out in the evening.

All these welcome sources of light have probably been produced by electricity. The light in your home may have come from another source. If you live in the country or near an oil field, you can name other sources of light.

In the daytime all sources of light except the sun seem unimportant. The sun is 93 million miles away; yet it is the most important source of light on earth.

Direct and Reflected Light. Light reaches our eyes either directly or by reflection. If you look at the lighted end of your flashlight, your eyes receive its light directly. This light enters the little black opening in your eye called the pupil and affects the nerves within. The message these nerves carry to the brain gives you a clear picture of the flashlight.

The light from the flashlight may also shine on a path. When it strikes the path, some of it may bounce away. Part of the light that is turned back by the path will also find its way through the pupil of your eye to the inside of your eye. This impression goes to the brain and produces a picture of the path.

When you see the light that an object gives off—directly or by reflection—you see the object. When you get up in the morning, you see your hands, the chair, the bed, and many other objects before you, because they reflect the sun's light just as the path reflects the flashlight. From where you are now, notice which part of the objects about you shines the brightest. The most light usually comes from the part of the object that is nearest the source of light.

Hot and Cold Light. Most sources of light are very hot. An electric-light bulb is not very hot, but it will burn a paper shade if it remains touching it long enough. Not all lights, however, are hot. If you hold a firefly in your hand while it is glowing, it will not burn your hand. The light of a firefly is a cold light. The firefly is its own source of light. It does not get its light from electricity or from the sun but from a chemical which is produced in its body.

Light Produced by Animals. Many other kinds of animals can produce their own light. If you have

had a sea voyage, you have probably noticed glowing specks here and there on the water at night. Some people call this the "burning" of the water. But these specks are really cold lights made by little plants and animals in the water.

Many larger sea animals—for example, jellyfish—glow at night. Scientists think that their light is somewhat like the light you see in a firefly or in its larva, the glowworm.

Many kinds of fish that live in the deep sea have glow lights. Fish have been seen with five rows of lights glowing along their sides. The great gulper eel has flaming red lights at the end of its tail.

Perhaps these lights help the fish to find their way around in the darkness of the deep ocean. Sunlight

can go several hundred feet through the water, but the deepest parts of the ocean would be pitch dark if it were not for the glow lights of sea animals. Divers say that these lights make a very strange and beautiful glow as they flash through the dark ocean waters.

Not very much is known about the glow lights on fish, but scientists believe that they are cold lights like those in fireflies. A glow light on a fish may sometimes scare away an enemy fish. At other times it may attract an enemy and in this way help the fish to find its dinner.

Paints That Glow in the Dark. Not long ago some scientists thought that they would be able to produce a cheap light if they copied the light of fireflies. They made a paint of chemicals that produce a cold, greenish light and painted the walls of a room with it. They found that the paint was not very useful, however, because the glow did not last long.

Today certain other chemicals are used to make paints that will glow in the dark. Have you ever seen a clock or a watch by which you can tell time in the dark? The numbers and the hands on the clock glow at night because they have been covered with a paint that has radium in it. Only a very small amount of radium is needed. In fact, one

hundred thousand times as much paint as radium is used. Of course the amount of radium used is very, very small.

Chemists have also made paints that glow without using radium. Pictures and ornaments, airplane dials, and even some dress materials can be painted with paint containing chemicals that make them glow in the dark. Walls in factories might be painted with this kind of paint for purposes of safety. Suppose the rooms were filled with many dangerous machines. If the electric lights should go out, the workers would be able to find their way to safety by the light from the walls. Can you name ways in which light is used to serve safety in your home, in your school, and in your neighborhood?

Too Much Light

Protection of our own eyes is very important indeed. We see best when just the right amount of light comes to our eyes. When there is not enough light, we cannot see clearly. When there is too much light, we cannot see well either.

Have you ever faced the sun while having your picture taken? Do you remember how you squinted? Your eyes had to shut out some of that bright light. If you have to close your eyes, that is a good sign that your eyes are receiving too much light.

Lights are almost always hard on our eyes if we look right at them. If your study light shines into your eyes instead of on the page, your eyes may begin to water. Eyes may be injured not only from looking at the sun but from having too much light from any source. What is its source in the picture below?

It is very dangerous to look directly at an arc light,

such as welders use, unless you are far away from it. One day a boy was going home from school. He saw welders working in the street in front of his home. They had placed their safety sign, DANGER, where passers-by could see it. But the boy wanted to see what they were doing and paid no attention to the sign. That night he awoke with burning, painful eyes. The doctor was able to treat them successfully, but the boy learned the hard way that he must watch out for safety signs and protect his eyes from arc lights with his hand as the boy in the picture has done.

Bright Reflections

As you have seen, the light we use does not always come directly from its source. It is reflected to us from some object that it shines on.

City people sometimes receive light in a room that is on a court, out of range of the sun. Light from the sun has struck a high window which reflects the light into the room.

Reflected light can be almost as bright as direct light. When the sun shines on snow or water, the reflected light may be strong enough to injure the eyes. This is why people sometimes wear dark glasses when hiking in the snow or when boating.

If you should look at the sun in a mirror, its reflection would dazzle you as much as it would if you looked at the sun itself. Looking at a welder's light in a mirror would injure the eyes in the same way that they would be injured by the direct light.

Look around a sunny room. What objects send back the brightest reflections? Hold a piece of tin, a glass of water, a piece of shiny, white paper and other objects in the sunshine. Which gives off the brightest reflections? Why?

The brightness of a reflection depends on how bright the light is at its source, how good the reflector is, and how near the object is to the source of light.

Objects that are smooth have better reflections than curved or rough surfaces.

Mirrors

What Makes a Mirror? A quiet pool of water was man's first mirror. A flat piece of metal, probably silver, came to be used as a mirror later. Metal mir-

rors were known long before people learned to make glass ones. They were harder to keep clean because the metals used turned dark after they were exposed to the air for a while. You know how dark a silver knife will get if you do not polish it often. It was this fact that may have led to the use of glass as a mirror. Perhaps the first glass mirrors were made when someone suggested covering metal with glass to keep it clean, the way we cover a photograph.

The glass mirrors that we use every day have a thin coating of metal on the back of them. The metals mercury and silver are used most often. If this covering were scraped off, the mirror would be ruined, because the glass could not reflect enough light. There would be nothing to keep the light from passing through the glass.

A piece of clear glass will reflect light if it stands against something that will not let the light pass through it. Try standing a piece of glass—for example, a windowpane—against the blackboard. Can you see yourself in it? Is your reflection as clear as it would be in a mirror with metal on the back?

Panes of glass do not turn back enough light to allow us to see ourselves in them clearly. If we want a clear reflection of ourselves, we must use a clean, polished mirror with a good back. Most of the mirrors in our homes and school give clear reflections.

Even though the reflection is clear, it will not be as clear as the object is when you look at it directly.

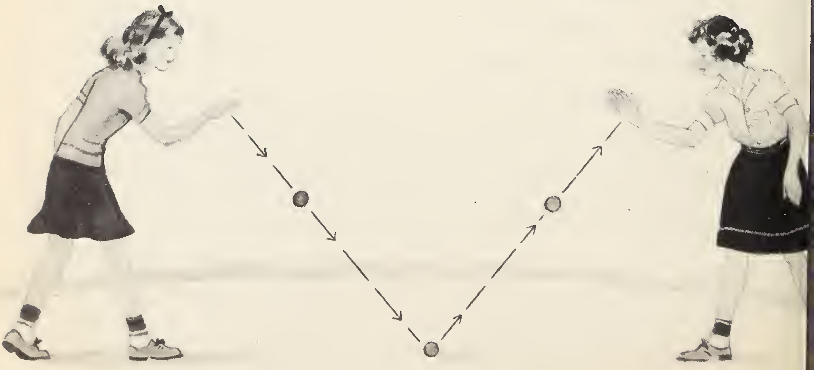
The Reflection in the Mirror. How do we know that an object—for example, a mirror—turns back, or reflects, light that falls on it? Look in a mirror. Raise your right arm. In the mirror the arm opposite your right arm is raised. Blink your right eye. Which eye blinks back at you? The entire figure in the mirror is completely turned around.

Hold a printed page facing the mirror. Can you read it? Print the words *reflection* and *mirror* backwards. Read what you have written by holding your paper facing the mirror. The reflection of the writing is turned around.

Did you ever wish that you had eyes in the back of your head? Look in a mirror and you will see some of the things that are behind you. You can see things at your side too without turning your head.

Light reflected from a mirror acts somewhat like a bouncing ball. If you drop a rubber ball directly down from your hand to the smooth pavement, it will bounce up to your hand. When light rays hit a mirror from directly in front of the mirror, they will return over the same path.

What happens when you throw a ball so that it hits the pavement a few feet away from you? You have thrown it down at an angle. Does it come back to your hand, or does it go toward your friend who is playing ball opposite you? Let one person stand on each side of a mirror where he cannot see his own reflection. While neither person can see his own re-



flection, he can see the reflection of the other. How is this possible?

Mirrors Have Many Uses. An automobile driver uses a mirror to help him drive safely. Does his mirror receive light directly or from an angle? The mirrors in the periscope of a submarine receive and reflect light rays at angles.

People sometimes use mirrors to make their rooms seem larger. A large mirror on the wall may give the appearance of a window or of a door leading into another room. Even though we know that there is no other room, we have a feeling that there is an opening. Does a store in your community use a mirror in this way?

Curved Reflections. The kind of reflection received will depend upon whether the mirror is flat or curved. Smooth, curved surfaces reflect light just as well as flat ones do, but the light rays are bent in such a way that they change the vision of the object.

Someone in your class has probably seen the mirrors that are sometimes found in amusement parks or at fairs. One looking glass may make a person look very tall. Another will make him look very fat, or give him a large head and tiny feet, or big feet and a tiny head.

Perhaps you have seen yourself in the curved mirror of an automobile door. You have appeared to be a short, fat person when you are really not fat or short at all.

The kind of reflection received, then, will depend on the way a mirror is curved. A mirror that bends inward collects the rays in a smaller space than it would if it were flat. An electric light reflected by a mirror that curves in will give a stronger light than one reflected by a straight mirror. If the source of the reflection is a hot, bright light and the rays are focused on one small place they will become stronger, hotter, brighter. The sun's light reflected by such a curved mirror can set some things on fire. The picture below shows a boy trying to start a fire with a mirror.

Curved mirrors are used in many important ways. Some of the bright lights used to guide aviators have curved mirrors in them. Curved mirrors are used for lighting football fields for games played at night. They are also used in stage lights and in automobile lights. Many telescopes and microscopes use curved mirrors, too.

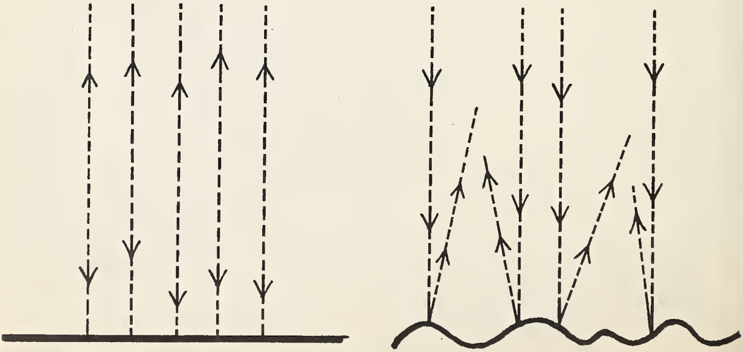
Mirrors that give the truest reflections must be clean and smooth in order not to scatter the light rays.

Scattered Reflections

Mirrors that give the clearest reflections are without scratches or dirt. Any uneven spots on a mirror will scatter the light rays and send the reflection in many different directions. The cave man learned that he could not see his reflection in a pool of water if the water was rough. A soldier carries his metal mirror in a case with a soft lining. If the metal should get scratched, he would no longer be able to see his reflection clearly.

When light strikes a rough surface, the rays are scattered. Even though a surface may seem very smooth, it may not be smooth enough to give back rays directly. Most surfaces are not smooth enough to reflect light evenly, therefore you cannot see your reflection clearly.

Life would be very unpleasant if all surfaces in our rooms reflected light without scattering it. A room with the usual amount of furniture and objects would have many bright lights in it. We would grow

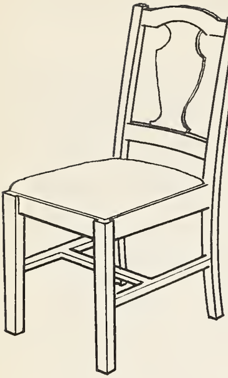


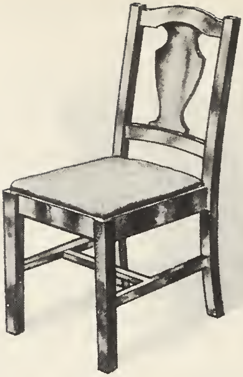
tired and uncomfortable if we had to look long at so much brightness.

Natural-colored wood or wood with ridges in it when painted a light color makes a more suitable trimming for a door or window than a shiny, plain, bright-colored surface. Papered or plastered walls with surfaces that are a little rough scatter light and are pleasing and restful to the eyes. Book paper that is slightly rough is easier to read than paper that is glossy. Schoolbooks are usually printed on paper that is a little rough. We say it has a dull finish. It gives a dull reflection, which is restful to the eyes. Write on a piece of shiny paper and then on a piece of dull-finished paper. Take the two sheets to a sunny window. On which is the writing more easily seen?

Look at a chair. Find the parts that have the brightest spots, or high lights, on them. If an artist intended to draw that chair, he would first study the bright spots very carefully. He would draw the high lights and the shaded parts as he saw them from where he was sitting. When he had finished, his picture would look like the real chair.

If he wished, he could draw the chair in another way. He might draw just the outline of the chair. His picture would show the shape of the chair, but it would not look real. Only when the artist draws the





light and dark parts will his picture look like the real object. Notice the high lights in the chair on the right.

Look around at people and things for examples of the way shiny reflections are used. Sometimes we want certain things to be shiny because we know that when they shine they are clean. Doorknobs, windows, chinaware, and pots and pans are usually shiny when they are clean. Certain things we want to be dull so that they will be restful to look at. We want dull paper in our schoolbooks. We want dull walls in our schoolroom, with a bright picture here and there. Some of the things we look at should be bright and shiny; others should be dull. If we should have the things about us all one way or the other, we would grow tired of them.

The Right Light for the Job

Have you ever heard of illumination engineers? "Illumination" means "lighting." Illumination engineers plan the lighting for theaters so that the stage will be lighted just right. They plan the lighting for large schools, stores, offices, factories, homes, and farms. They plan the right light for the work that is to be done there.

Each one of us needs to be the illumination engineer for the jobs that we have to do. We can plan so that we can have the right light for whatever we need to use our eyes for. We need to decide where to sit in order to get the best light to read by. We shall want to place the mirrors we use so that they will give us the best reflections and not hurt our eyes.

Light can be used in many ways to make our work easier. We can also use it for safety, to attract attention, to make our rooms cheerful, to protect our eyesight. No matter what we need to do, or what we like to do best, the right use of light should be considered first.

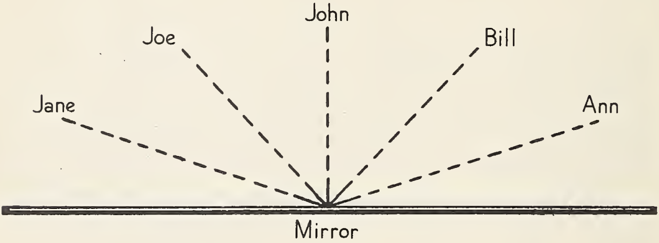
WHAT DO YOU THINK?

1. Make a list of things that give off their own light. Make another list of things that reflect light.

2. Imagine a world in which nothing reflects light. Can you describe such a place?

3. Do you wish that all surfaces were smooth and shiny? Why? Why not?

4. Whom would Jane see when she looked into the mirror? Whose reflection would each person see?



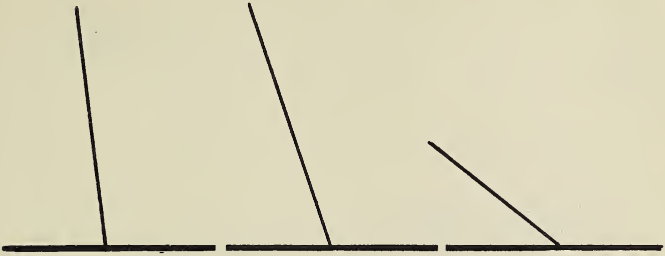
MORE THINGS TO DO

1. Make a mirror in a picture frame by putting tin foil behind the glass.

2. Watch for your reflection from smooth, shiny surfaces. Does your desk make a good mirror? Does a wet blackboard make a good one?

3. Copy the following picture on a piece of paper. Pretend that the bottom line is a mirror and that the

slanting lines are light rays. Draw lines to show how these light rays would be reflected from the mirror.

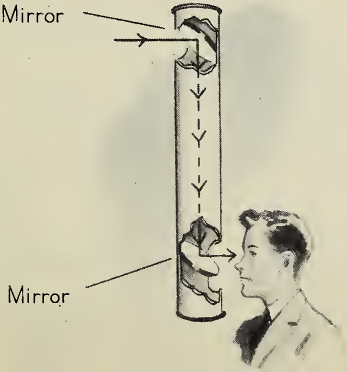


4. Look back in the chapter on electricity and see if you can find a new idea in lighting.

5. Describe different kinds of light bulbs which you have seen at home or at school. Look in a sewing machine, automobile, vacuum cleaner, and a flashlight. Do you know other places where a special kind of light is used for a special job?

6. Make a periscope in a cardboard tube by placing mirrors the way they are in the picture. The dotted line shows the path of light.

C6



Sounds All About Us

Sounds We Like

Much of our understanding comes to us because we can see. People sometimes say, "I see," when they mean, "I understand." Then sometimes a person will say, "I hear," when he really means, "I understand." In helping us to learn, our ears are second only to our eyes. Our sense of hearing brings us much enjoyment too—interesting radio programs, beautiful music, the sound of friendly voices.

Our Noisy Earth. On our planet a perfectly quiet place is very hard to find. Can you think of any place where there is not a sound?

Perhaps you are thinking of the forest. But there the leaves rustle when the wind blows. Birds sing and call to each other from the treetops. Little animals scamper about. All this causes sound.

A desert is a quiet place until the wind sweeps across the sands. Large bodies of water also may be still and quiet until winds make their waves break.

You may have noticed that wherever there is sound there is movement. When the leaves of the forest move back and forth, you hear a rustling sound. Woodpeckers' beaks tapping the roof or a tree at a great rate produce the rat-a-tat you know so well. A twig breaks as a squirrel jumps on it, and the sharp snap comes to us as another sound.

Sounds from Musical Instruments. If instruments are still, no music comes from them. But when a movable part of a musical instrument is set in motion, air waves begin to travel from that part. You have seen a drummer strike a drum so that the skin which is stretched across the top of it moves back and forth. This motion of the top of the drumhead is called vibration. The vibration of the drum skin sets air in motion, and as the air moves back and forth, it pushes the molecules of air next to it so that more air moves, or vibrates. These waves of air move out in all directions from the drum skin, much as ripples move out from the place where a stone strikes the water.

Of course you cannot see sound waves. They differ from the ripples in the water in another way too. Sound waves move up, down, and across—in fact, in all directions—while ripples move only across the surface of the water.

Sound waves can also be sent out from a flute. When you blow into the mouthpiece, shrill notes can be heard, because a short column of air moves, or vibrates.

Try to make a sound by blowing through a piece of grass that you hold tightly in front of your mouth. Some musical instruments have in them a thin strip, called a reed, which acts like the piece of grass. Reeds stretched across the mouthpieces of saxophones, oboes, and clarinets vibrate when air is blown against them. In this way the column of air in the tube of the instrument is made to move back and forth. This air vibrates far enough to reach your ear.

Bugles, cornets, trumpets, and other horns have no reeds in their mouthpieces. Instead the player makes his lips vibrate. You can make music by winding one layer of tissue paper around a comb and humming against it. Hold the comb close to your lips when you hum. Do you feel your lips vibrate?

Blow across the opening of an empty soda-water bottle. Can you make the air in the bottle vibrate enough to make a loud whistling sound?

Other types of instruments have strings. Piano keys are attached to hammers which strike strings so that they vibrate. Perhaps you can watch them move inside of a piano. If you carefully place a finger on a piano string, the vibrations will stop, and then the sound will stop. A violinist sets the strings in motion by moving a bow across them.

In all these different kinds of musical instruments something must move before sound can come from them. Examine as many instruments as you can to find the part or parts that move. As you examine them, you will find that different kinds of materials are used for the moving parts. Either vellum or the skin of an animal is stretched across the drum, and strings of catgut are used on the violin to send vibrations through the air and produce the sounds we hear when these instruments are played.

Soft and Loud Sounds

When some things move we do not hear them, because they do not set enough air in motion. If someone speaks to you very, very softly, the air waves set in motion may not be strong enough to reach your ear. The loudness of a sound depends upon the amount of force sent against the object that is intended to vibrate.

Leaves stirring gently in the breeze may not vibrate enough to make a noise that you can hear; yet the wind can be strong enough to whistle around corners.

Compare the volume of your voice with a stone striking the water. A large stone that strikes the water hard will make more ripples than a tiny pebble. A shout that can be heard a hundred yards away will cause 2200 tons of air to vibrate on its journey.

You can experiment with the loudness of sounds by tying a string to a tablespoon. Use about three feet of string and tie the spoon so that it will be at the center of the string. Light-weight string is better than cord. Hold the ends of the string in your ears and lean forward so that the spoon taps very lightly the edge of a table. Do you hear beautiful chimes?

Lean forward again and let the spoon strike the

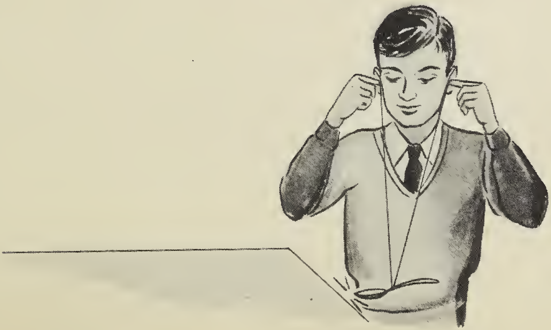


table harder. Stronger vibrations travel through the string to your ears. Does this make a difference in the loudness of the sound? Is the tone any higher or lower than it was before?

High and Low Sounds

When you made the spoon vibrate harder, it did not produce a higher or a lower note. It simply made a louder noise.

The highness or lowness of a note is called pitch. To find out how pitch can be changed, you can try several interesting experiments.

Pitch Depends on the Speed of the Vibrations. If you substitute a teaspoon for a tablespoon in the previous experiment, you will hear a change in pitch. Which makes the higher chime? The shorter, lighter spoon when vibrated at a faster rate than the longer, heavier spoon will produce a higher sound.

Look at the strings of a piano. Strike different keys and try to find the string that vibrates for each one. Which string made a low note? Notice the appearance of the string that produces this sound. Find a string that has a high pitch. Notice the difference in the length of this string and the length of the string with the low pitch.

When strings are tightened, they vibrate faster and their pitch changes. A piano-tuner turns the pegs to which piano strings are fastened until the strings vibrate correctly. Perhaps someone in your class will show the class how he tunes his violin. Ask him to show you how he gets high pitches and low pitches.

A clarinet player will show you little doors, or holes, in his instrument. These holes can be opened and closed to change the length of the column of air that is set in motion when he blows into the clarinet. Players put their fingers over these holes. Where on the clarinet would you place your finger to make a high note?

You can try a simple experiment which will produce high and low sounds. Blow across the mouths of several soda-water bottles that have different amounts of water in them. Now put some water in a taller bottle. Can you tell why the sounds are different?

So you see that the pitch of stringed instruments depends on the size, the length, and the tightness of the strings, for these determine the speed of the vibrations. The pitch of wind instruments and reed instruments depends on the length of the air columns that vibrate inside of them. Short air columns vibrate fast. The pitch of other instruments—for example, the drum—will depend on the size and the tightness of the material that vibrates. The tone that comes from an instrument will always depend on the materials of which the instrument is made. For example, certain kinds of wood will not produce good musical tones.

Movements May Be Too Slow or Too Fast to Be Heard. Hold your hand near your ear and move your hand very slowly through the air. Do you hear anything? Air waves are vibrating as your hand moves, but no sound can be heard. Now move your hand back and forth as fast as you can. Listen for a low, soft sound. When there are as many as twenty vibrations a second, you should be able to hear a sound. Slower vibrations produce notes that are too low to be heard by most human ears.

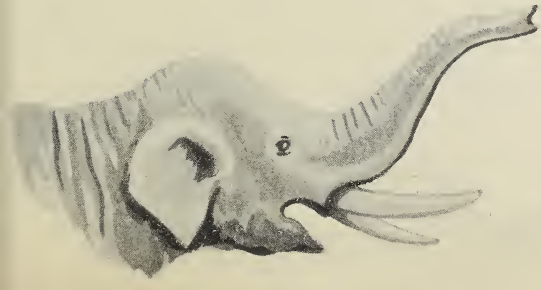
Have you seen whistles that you cannot hear when they are blown? Some people use them to call their dogs. The whistles set air vibrating so fast that a human being cannot hear a sound when they are blown. Dogs can hear these faster vibrations; so good dogs come running home.

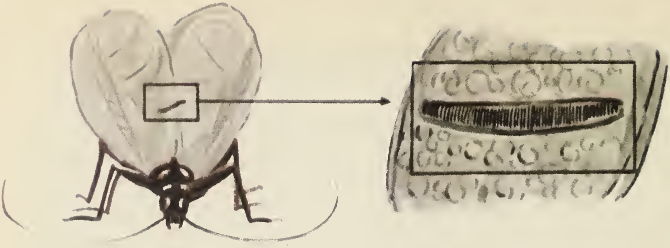
The high noises which guide the flight of bats are caused by such fast vibrations that we cannot hear them. We probably miss part of a hummingbird's song too.

Many people can hear sounds made by things that can vibrate 20,000 times a second. Young people and specially trained musicians can sometimes hear sounds caused by 32,000 vibrations per second. But such sounds are not always pleasing. They are often squeaks and hisses. Sounds cease to be pleasant to our ears when they are caused by more than 5000 vibrations a second.

Animal Sounds

A rooster's crowing, an elephant's trumpeting, and a cat's meowing can be heard, although they are very different sounds. All sounds are made by vibra-





tions which set the air moving back and forth at a speed that allows us to hear them.

Crickets manage to make themselves heard in a strange way. One wing is moved across the other wing in much the same way that a violinist uses a bow on the strings of his violin. This rubbing of one wing, the scraper, across the rough place on the other wing makes the cricket's chirp. The rough place is called a file. When the scraper and the file grate against each other, the wings vibrate, and the call of the cricket reaches our ears.

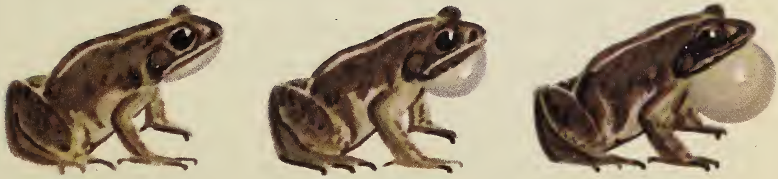
Mosquitoes, bees, and flies make a noise by moving their wings very fast. This sound is very distinct when they buzz around your room in the quiet of the night.

Rattlesnakes have their special way of making noise. They move the rattles on their tails fast enough to make vibrations that can be heard by their enemies. The rattles are hollow pieces that vibrate as the snake revolves its tail. Sometimes the noise is shrill enough to be heard twenty yards away.

Sounds made by some animals in the forest are too high to be heard by our ears. However, there are other animals that make lower sounds.

Animals with Vocal Cords. Many kinds of snakes make a hissing sound with their thin vocal cords. Pieces of skin are stretched across the air tube through which a snake breathes. When a snake hisses, it stretches these cords so tight that they vibrate.

Frogs are noisier than snakes. They can croak under water as well as on land, because they do not have to open their mouths to make a loud noise. A frog croaks by using an air sac that is somewhat like a bag. The picture of the frog on this page shows you where the sac is located. As the frog croaks, this sac fills like a balloon with air that is forced out past its vocal cords. When it makes a loud noise, the sac is large. Sometimes the sac grows so large that it looks as though it might burst. Without this vocal sac a frog could not croak loudly. When it stops forcing air out, the sac shrinks, and its throat again becomes smooth and small.



Many other animals have vocal cords. A dog uses its vocal cords to bark, and a wolf howls with its vocal cords. The moo of a cow, the quack of a duck, the song of a robin, the tiny squeak of a mouse, and the great roar of a lion are all made by vibrating vocal cords.

Vibrations for Talking. When you talk, your vocal cords are pulled tightly across your voice box, or Adam's apple. As the air from your lungs passes between the cords, they vibrate. Air vibrations are changed into words by the movement of your teeth, tongue, and lips. Try to talk without moving your mouth or your tongue.

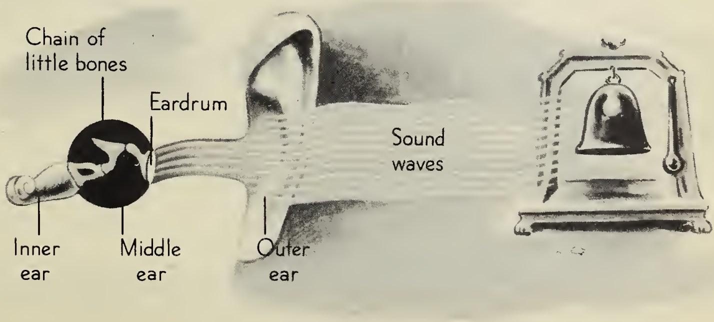
Some people move their lips very little when they talk. They mumble and jumble their words together so that no one can understand them. People who talk in this manner can improve their speech by opening the mouth wider. The vibrations need to get out of the throat through the mouth.

Now say something while you hold your nose. Nasal tones are unpleasant. When you send the right amount of air through your nasal passages your voice sounds clear.

People sometimes have unpleasant voices because they pitch their voices too high or because they talk louder than is necessary. You can improve the quality of your voice by learning how to avoid making these unpleasant sounds. Listen to yourself as you read this sentence in your natural speaking voice. Now experiment with your voice to see if you can make it low, soft, and clear. Just as a violinist practices until he can play with great skill, you can practice with your speaking voice until it is distinct and pleasant. Move your lips carefully and send the correct amount of air through your nose and lips.

We Hear by Vibrations, Too

When the sound of a voice reaches our ears, there are many vibrations in the air. Some of these waves are caught by the outer ear, the part of your ear that you see when you look in a mirror. The waves reaching the outer ear travel through a tube and push against a thin skinlike material, called a membrane, which is stretched across the air tube in the ear. This is the eardrum, which vibrates somewhat like the vellum stretched across the drum.



Vibrations of our eardrums set a chain of three little bones in motion. All three bones fit into a cavity about the size of a grain of corn. From here the vibrations travel to a liquid which is housed in a part of the ear which looks like a snail shell. As the liquid moves back and forth, many nerves pick up the sound message and carry it to the brain. Then we hear the voice.

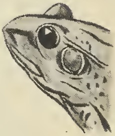
How Man Has Learned to Protect His Ears. Since our eardrums play so important a part in our hearing, we must be careful not to injure these delicate membranes. Soft wax forms in our ears to protect the membranes and to keep them soft. However, this wax cannot protect our ears from the bad effects of very loud noises.

If you should shout in a friend's ear, it would be painful, for many pounds of air would push against his eardrum and make it vibrate very fast. Soldiers

sometimes put their fingers in their ears to protect their eardrums from the roar of guns. Loud noises may break eardrums and even cause permanent deafness.

Imagine someone pounding on a drum that has a thin piece of skin stretched across it. A sharp object could easily break the drum. Your eardrum is very thin, too. Never stick anything sharp into your ear, for you might injure your eardrum or make a hole in it. Even though small holes in eardrums sometimes heal, it is important to protect your ears. If the part which vibrates should be destroyed, you would become very deaf.

Some kinds of bacteria cause infection if they are allowed to get into the ear. Earaches that are not properly taken care of may result in a serious condition.



How Animal Hearing Differs from Ours. Some animals hear differently from the way we hear. They have no outer ear to collect sound waves.

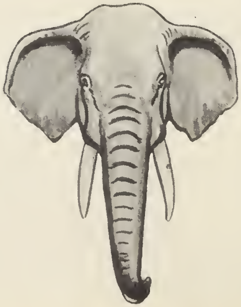
Feathers cover the openings of a bird's ears. A frog's ears are flat, round surfaces behind his eyes. The ears of crickets and katydids are not like ours or the frogs'. Crickets hear with a part of their front legs.

Many scientists have made tests to see how well different kinds of animals hear. They believe that a great many animals cannot hear at all.

Earthworms were allowed to burrow into soil that had been put in flowerpots. When a note was struck on a piano near by, the earthworms were not active. However, when the flowerpots were placed on the piano, music sent the earthworms crawling out of their burrows. Scientists think that the worms felt the vibrations in much the same way that you can feel them if you place your finger on a piano string when someone strikes the key. They doubt that earthworms have any special organs that they use for hearing.

Some snakes seem to hear whistles, but many pay no attention to them. Scientists are not certain that they can hear other noises.

A rabbit's ears collect sounds and help to protect him from noisy enemies. Can you tell how? Name a large animal that has very small ears and a very tiny animal that has large ears. Can an elephant hear as well as a mouse? Can you name several



animals that use their ears for protection? Name two that hear better than human beings.

Many animals can move their ears so that they are better able to tell the direction from which a sound is coming. Watch the ears of dogs and horses as they move them to catch sound waves.

Man Can Prevent Many Unpleasant Sounds

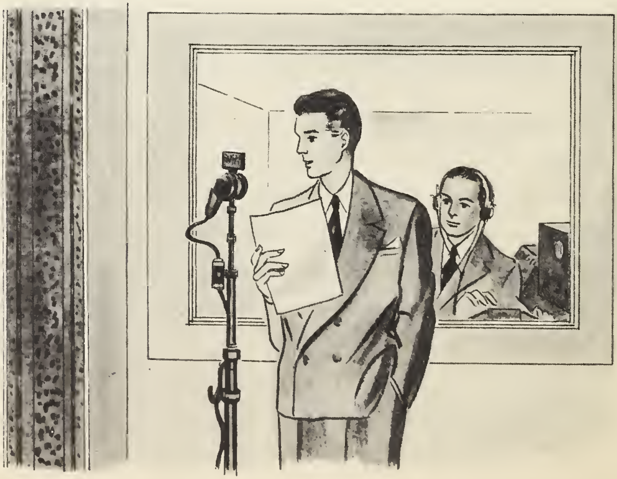
If people had big ears like elephants and rabbits, and if they could move them, they could probably hear better. Perhaps they would hear too well to live comfortably in this noisy world. Sometimes too many vibrations reach our ears at one time. Noises that interrupt what we want to hear or that remind us of unpleasant experiences can be very disagreeable.

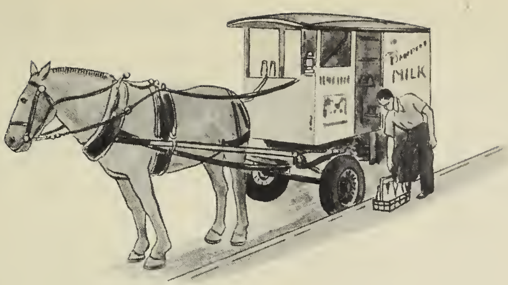
Some noises make us feel happy, even though they are not a bit more musical than the ones that bother us. Some people like to hear trains, because they are reminded of vacations. Riveting may be a pleasant sound to the proud owner of a shipyard.

Listening to any sound makes us use energy. We use energy to receive vibrations even when we do not know that we are receiving them. This is a good reason for trying to get rid of unnecessary noises when we sleep. Loud and monotonous sounds tire most people.

Sometimes auditoriums are made less noisy by hanging heavy curtains in places where sounds echo, and by using cloth material on the seats and carpets on the floor. Special wall materials are sometimes used in large rooms to prevent echoes. Many of these materials have thousands of small holes in their surfaces which collect the sounds. Felt and other materials used inside of walls help to keep rooms quiet. Of course soft voices help, too.

When walls are thin, vibrations may shake the whole wall and disturb the air currents in the next room. Sound can travel through cracks in plastered





walls and around the edges of doors and windows. Studios for radio broadcasts have thick walls to shut out sounds.

The clangs and bangs of our city streets are being quieted. Heavy rubber tires on the milkman's wagon and rubber shoes on the hoofs of his horse help to decrease street noise. Can you think of other ways in which unnecessary noise is being silenced?

Scientists are helping us to prevent the noises which we do not like. Radios are bringing us more of the sounds that we enjoy.

WHAT DO YOU THINK?

1. What do you think the world would be like if people had never learned to talk?

2. Would you like to hear a sound every time an object vibrated? Explain your answer.

3. Why do sounds differ?

4. What instruments can send sound around the world?

5. People often cup their hands around their ears to soften sounds. How is the sound softened?

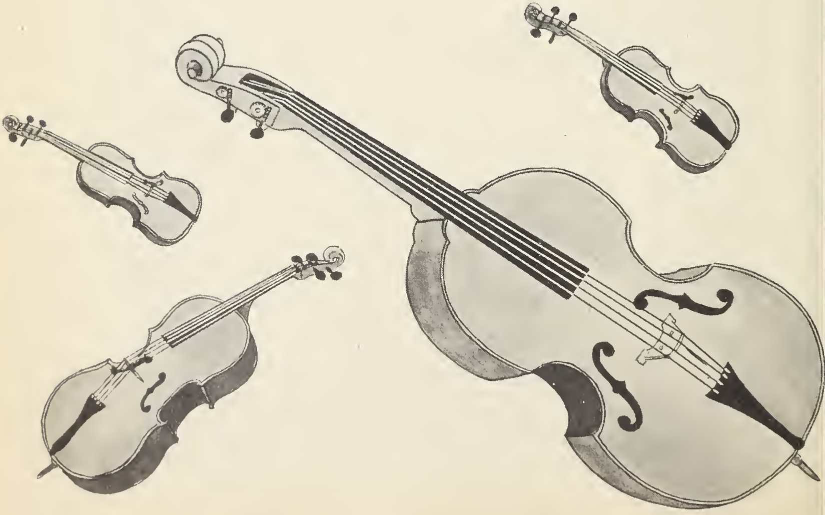
6. Why can't you hear a sound unless something vibrates?

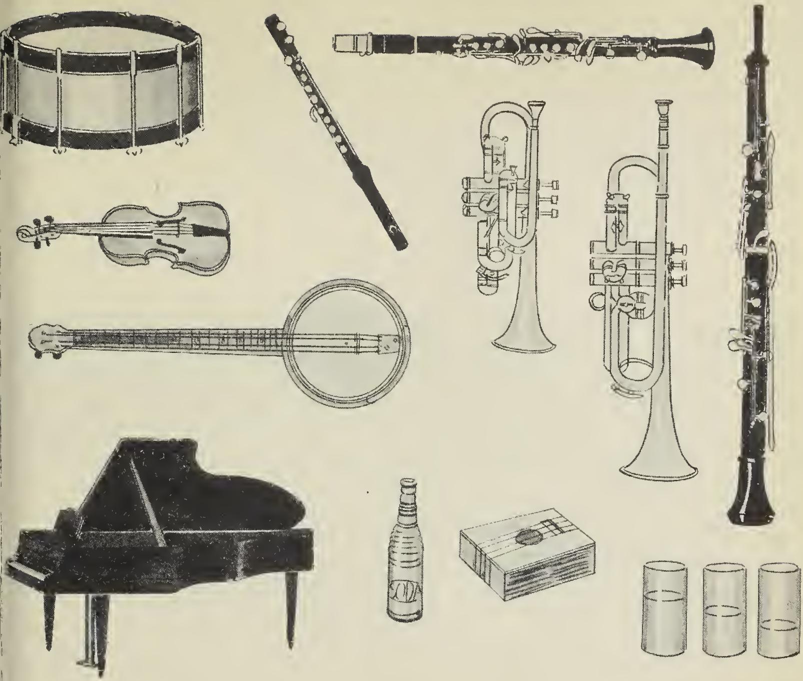
7. Find out which of the instruments in the picture below will play the lowest note. Can you tell why?

8. Why do mayors of large cities try to stop all unnecessary noise?

MORE THINGS TO DO

1. Try to make a simple string telephone by punching holes in the bottom of two tin cans. Fasten the cans by putting one end of a long piece of string





through each hole. Knot the ends of the string. Separate the cans as far as possible. Talk into one can while someone holds the other to his ear.

2. Find out what the pedals of the piano are used for. Ask a music teacher to help you.

3. Play for your class on a homemade musical instrument made of bottles or on a cigar-box banjo.

4. What vibrates in each of the instruments in the picture above?

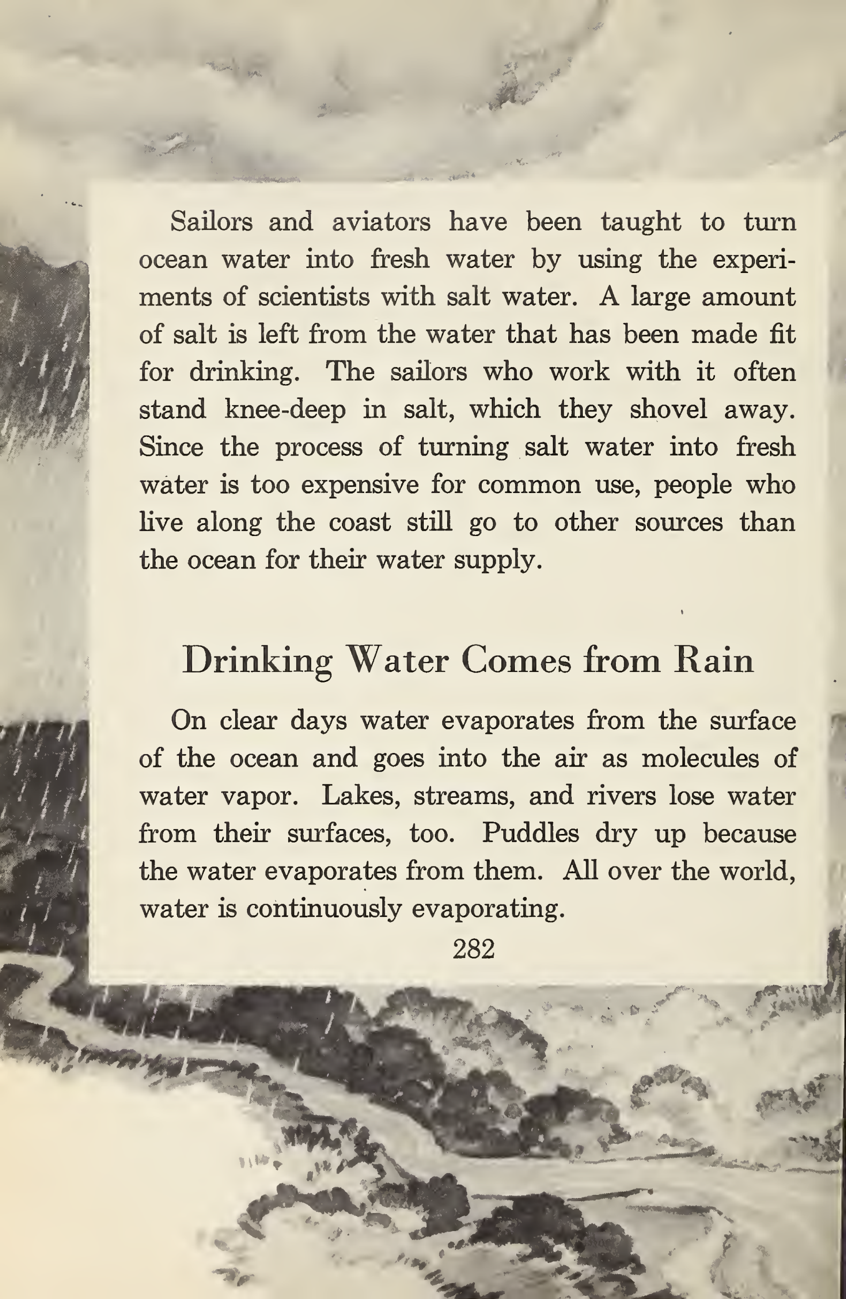
The Water We Drink

Ocean Water Is Not Good for Drinking

Early in this book you read about the ocean and about the animals and plants that live in it. But the most important part of the ocean is the water, although it is not fit to drink.

Shipwrecked sailors and aviators know the truth of the statement, "Water, water everywhere, nor any drop to drink." They know that salty water makes one more thirsty than no water at all. It cannot even be used for washing!

Put several tablespoonfuls of table salt in a large pan; fill the pan with water and stir the salt into it. See if you can make suds in this salty water as you try to soap and wash your hands.



Sailors and aviators have been taught to turn ocean water into fresh water by using the experiments of scientists with salt water. A large amount of salt is left from the water that has been made fit for drinking. The sailors who work with it often stand knee-deep in salt, which they shovel away. Since the process of turning salt water into fresh water is too expensive for common use, people who live along the coast still go to other sources than the ocean for their water supply.

Drinking Water Comes from Rain

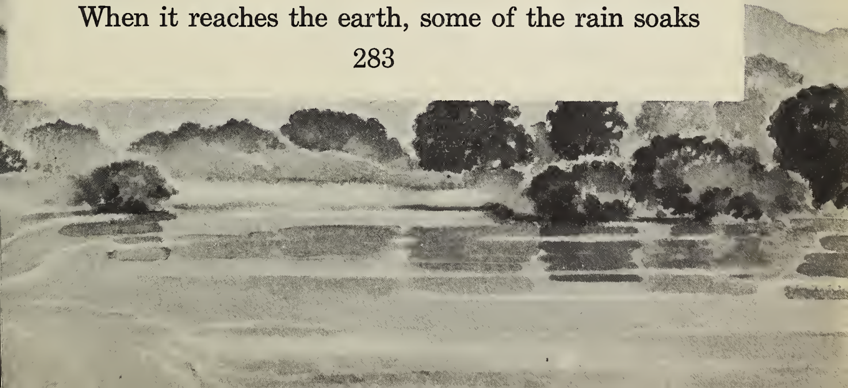
On clear days water evaporates from the surface of the ocean and goes into the air as molecules of water vapor. Lakes, streams, and rivers lose water from their surfaces, too. Puddles dry up because the water evaporates from them. All over the world, water is continuously evaporating.

When water goes into the air as a vapor or gas, it becomes purer, because salt, other chemicals, and dirt are left behind, just as salt is left in the pan when salty water evaporates. Water vapor rises; then it collects to form drops, which fall as snow or rain. Most of the water we drink has at some time fallen as rain.

New rain comes from old rain. Over and over again water evaporates from the earth and goes to the clouds to return as rain or snow. Even water that has been used goes back to the clouds.

Water from the clouds sometimes travels a long distance through the air before it reaches the earth. As it moves about, dust and germs may get into it before it falls as rain. Scientists have found that water vapor uses tiny bits of dust around which to form drops. Rain, then, is not entirely clean when it begins to fall.

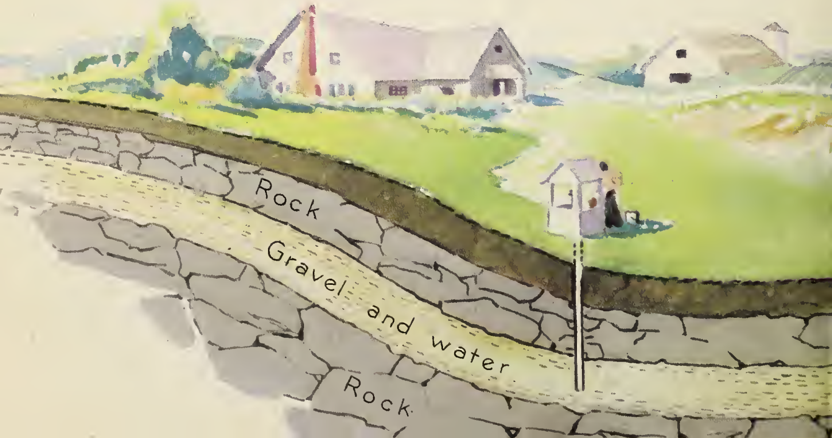
When it reaches the earth, some of the rain soaks



into the soil. Part of this water sinks until it reaches a layer of rock in the earth, where it collects. Traveling underground, this water may finally come to a lake or a river, or it may become a spring. You have seen water pushing its way from underground as a gently rising spring.

How People on Farms Get Water. People who live in the country or in villages often use water from springs. This water may be piped into their homes. If there is no spring water to use, a farmer may dig a well. He may have to dig until he reaches ground water, which is a layer of water in the earth. Some wells are deeper than others, because the level of ground water is different in different places.

Pumps are usually used to force the water out of wells. If a well is deep, however, water may rush out of it without being pumped. Ground water from a hill may flow down between layers of rock that



serve as a pipe. When the water reaches a well in the valley, it will flow out of the well. Sometimes there is enough pressure in the flow of water to make a fountain. This is called a flowing or artesian well. Because artesian wells are usually deep, water from them is purer than water from shallow wells. San Antonio, Texas, and certain smaller cities get their water supply from artesian wells.

How Water Comes to Cities. For most cities, however, engineers must carefully plan water systems that bring water from a long distance. From high in the mountains, one or two hundred miles away, water may flow down to cities that have no near-by sources of fresh water.

New York City, Los Angeles, and San Francisco have built lakes, called reservoirs, to collect the snow and rain which drains off hillsides, and the water from small streams. From these reservoirs, water is carried through large tunnels to places near the city where it is stored.

The water in these artificial mountain lakes does not have to be pumped to the cities. The force of gravity pulls it to the reservoirs where it is stored. Sometimes these storage reservoirs are on ground that is higher than the tallest city building. Water that flows down underground will come up again in

water pipes until it is just as high as the level of the reservoir. It rises this high because water tends to seek its own level.

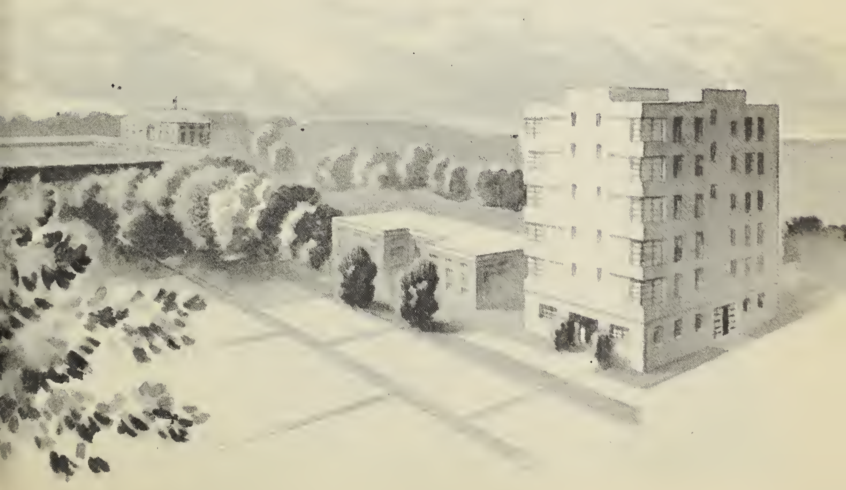
You can see how water will rise in pipes by connecting two funnels with a rubber tube. Select a person who is about your height. Hold the funnels so that he and you can see over the tops of them. Have the third person pour water into one of the funnels. The funnels may have to be raised and lowered so that the water will push the air out of the tube. Ask the person who holds the other funnel to watch the water come up into his funnel.

Pretend that one funnel is the storage reservoir and that the tube is an underground pipe. Think of the other funnel as a tall building in a city. See if water reaches the "building" when it is held at the same level as the "reservoir."

If a building were higher than the level of the water in a reservoir, would water reach the top floor without being pumped? Move one funnel up and down and watch the level of the water. Compare it with the level of the water in the other funnel. Does the height of the water change?

In cities where storage reservoirs are not on high ground, pumps are used to force the water through pipes. There is enough pressure to make the water reach the faucets on the top floors of high buildings. In this way water comes to people from reservoirs or lakes on lower ground.

Cleveland, Chicago, Detroit, and Toronto are among the cities that receive their water from lakes. Through pipes deep in the lakes, water is carried to pumping stations. Many cities get their water from near-by rivers. St. Louis, Philadelphia, Atlanta, New Orleans, Quebec, and other cities use river water.



Making Water Safe for Drinking

Why We Need to Purify Water. After water is carried by pipes from reservoirs in the mountains, or from lakes, rivers, wells, and springs, we must be sure that it is pure. The early settlers were satisfied with clear, sparkling water, but scientists have found that many disease germs may live in water that appears clean.

If you should look at a drop of spring water under a microscope, it might look like the water in the picture on this page. There is more than water in this drop. The germs in it are so small that you would not be able to see them without a microscope, but they could make you very sick.

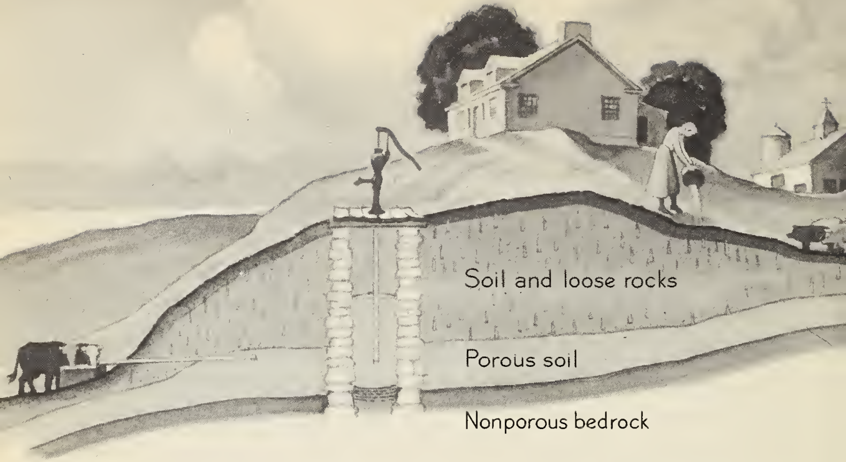
People who drink water with typhoid germs in it may become dangerously ill because these bacteria multiply in their intestines. Many deaths have been caused by typhoid germs. During the Spanish American War so many more soldiers died from

typhoid fever than from bullets that scientists began to study ways of treating water to kill the germs.

About fifty years ago in a town in Pennsylvania, more than a thousand people had typhoid fever, and more than a hundred of them died. Physicians decided that the drinking water from a reservoir in the near-by hills must contain germs. They investigated the land near the water supply and found that a man who lived in a cabin near the reservoir threw wastes from his home out into the snow. This man had typhoid fever. When the snow melted, the water containing the waste with typhoid germs in it ran into the reservoir. People in the town had drunk these germs in their drinking water.

How Wells and Springs Are Protected from Germs. People need to be sure that the water in their wells is protected from seeping water containing disease germs. Sometimes water seeps through the ground from a barnyard or stable, and the bacteria are carried into clear, pure water. Wells are made safe for use if they are lined with brick and concrete, and covered above with an iron platform. Then the impure water cannot seep into a well from the sides or top.

This way of protecting a well, however, is not always entirely satisfactory. Even though a well is properly built and the pump is located on a hill, im-



pure water can come out of it. Follow the path of the water in the picture above. How do you think disease germs might get into this water?

You can see that water from all wells should be tested from time to time under a microscope to make certain that the water is safe for drinking. Men from the board of health in certain cities travel to near-by farms to test water in wells and springs without charge. Since the water may become unsafe even after a test is made, a chemical is sometimes added to the well water to kill any germs that may be in it. Then the citizens can be sure that the water is entirely safe for use.

Just as well water is tested by the board of health, water from streams and springs should also be examined to see whether or not it is pure enough to drink.

In many places scouts have helped to protect people from impure drinking water by sending samples of water to the boards of health in near-by towns. Perhaps you have noticed signs near springs that tell whether the water is safe. Probably they were posted by the board of health to inform people who might pass that way about the purity of the water.

An Easy Way to Purify Water. If you are camping near a spring or well and are not sure that the water is pure, you can kill the bacteria by boiling the water twenty minutes. Most of the dangerous germs in it will be killed by the heat. After you have drunk boiled water, have you noticed that it has a flat taste? Boiled water tastes flat because the air has been forced out of it. Try pouring a glassful of boiled water back and forth between two glasses to put air back into it. Does it taste better?

To have to boil water for a large city would certainly not be a satisfactory plan. To require

every family in a city to boil its drinking water would not be a good plan either.

In keeping a pure water supply cities, then, have more problems than farms or camps, because their supply comes from open rivers, lakes, and reservoirs. Such sources of water may almost dry up in the summertime, and more germs may breed. If sewage from homes and factories has entered these bodies of water, the cities must use other means of having pure water.

Purifying Water in Cities. As water stands in reservoirs, some of the solid materials and germs fall to the bottom. The clean water is then drained off. Sometimes this water is piped to other reservoirs, so that the sun will shine on it and air will be mixed with it to destroy the germs. Most cities also filter their water by straining it through gravel and sand. As the water seeps through the filter, solid materials are left on the sand and gravel.

You can filter water. Put a layer of gravel in a funnel, and on top of the gravel or crushed rock put a layer of sand. Pour muddy water into the funnel and collect the water that drips through. Does

this water look like the muddy water that has not been filtered? You can see that the filtered water has lost part of its impurities. If we look at this sample of filtered water under the microscope, however, we still find bacteria. To make sure that these harmful bacteria are dead, chemicals must be used to kill them.

To kill germs, most filtered drinking water used in cities is treated with ammonia or chlorine. Usually less than one drop of chlorine is added to one million drops of water. If you live in a city, about one tablespoonful of chlorine may be found in the water you use during a whole year.

Has water in a swimming pool ever made your eyes burn or sting? Water in most pools is treated with chlorine, and this chemical may irritate your eyes. Without it, however, germs would breed rapidly. Adding chlorine to water is the most effective way to purify large amounts of water, but too much of this chemical is harmful to people as well as to germs. Laboratory tests are therefore made daily by chemists to find how much chlorine is needed to make water safe to drink. To improve the taste, the water is forced through a spray or fountain so that more air will get into it.

So we can see that cities secure a safe water supply by filtering, spraying water into the air, storing it, and by treating it with chemicals.

People on farms and in towns must also make their water safe to use. Great care should be taken to have the water in your home pure enough to drink. Many lives are saved annually by preventing the spread of diseases caused by germs that thrive in water. A safe water supply is one of man's greatest accomplishments in the war against disease.

MORE THINGS TO DO

1. Put a tablespoonful of salt in a pan of water, and place a lid on the pan; heat the water and let it boil for a while. Then use a pot holder or towel to remove the lid from the pan. Try to keep a few

drops of water that have formed on the lid. After they have cooled, taste these drops. When the water boils, salt is left in the pan. When ocean water evaporates, salt is left in the ocean. This experiment explains, then, why rain is not salty.

2. Plan a trip to the nearest water-purification plant. Write for an invitation, and get information before you make the trip, so that you will know what you can expect to see.

3. Write to different cities for information about their water supply.

MORE THINGS TO FIND OUT

1. How are aviators equipped to produce fresh water?

2. Is your drinking water purified? Is it tested frequently? Consult the department of health in your community.

3. From where does your drinking water come? Does the supply become low during periods of dry weather?

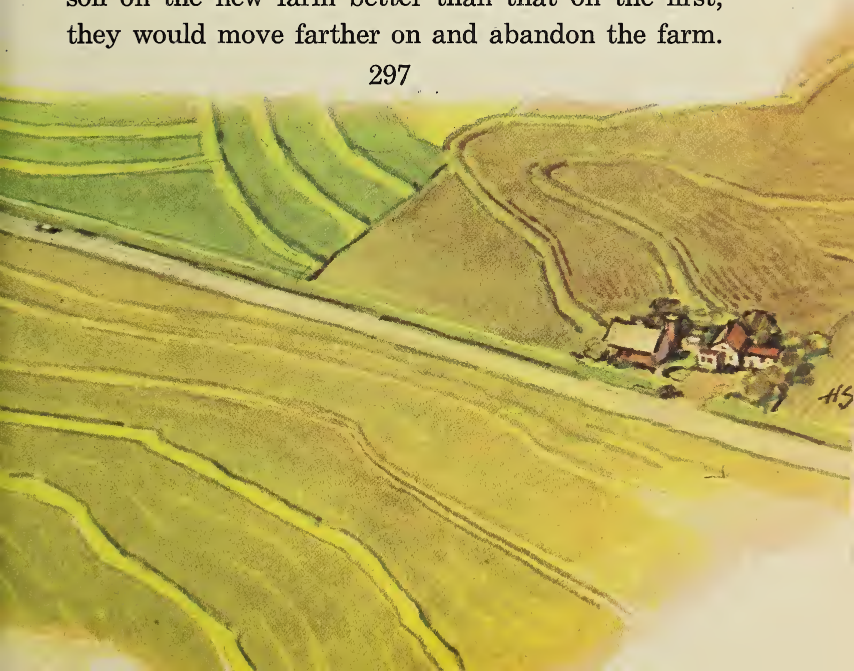
4. The next time you drink water from a well on a farm, ask the farmer to show you where he believes the ground water is located that flows into his well.

Saving the Soil

Lost Soil

When Columbus discovered America, the Indians were working with stone tools to cultivate the soil. They could cut down trees and bushes, hew their canoes out of logs, and till the soil with these crude tools. But not until this country began to be settled by white men, who used metal tools, were the forests cut and fields cultivated on a large scale.

When the Pilgrims landed on the eastern coast of the United States, they selected the best land they could find and cleared it for growing food crops. If the soil was not easy to cultivate, the pioneers moved inland to find richer land. If they did not find the soil on the new farm better than that on the first, they would move farther on and abandon the farm.



As the pioneers moved westward to settle, they cut down the forests. When the trees were gone, there was nothing to keep the rain from carrying the soil from the top of rolling land and down a thousand hillsides.

On the prairies the grass that held the soil in place was destroyed by the grazing of too many cattle and sheep. Without grass to hold the dirt, it was carried away by the winds.

Scientists became alarmed at this loss of soil and vegetation. They tried to find ways by which man could work with nature to save the soil.

New Soil from Rocks

Before we learn about the ways the scientists found to save the soil, we need to understand how soil has been forming for millions of years.

Ice Can Break Rocks. Have you ever filled a bottle with water, capped it, and put it outside on a cold day? When water freezes, it takes up more space, or expands. As it takes up more room, the ice may push on the glass until it cracks the bottle. Or it may break the cap. Water that freezes in cracks of rocks can break them into smaller pieces. Crumbled rocks become part of the soil.

Hot Days and Cold Nights May Break Rocks. Even in the summer when there is no freezing, rocks will break into smaller pieces. They break in much the same way that a hot pudding dish does when placed in a refrigerator. When something hot is poured into a dish, the heat makes the dish expand. Then if it is put in a very cold place, the outside of the dish will begin to contract, or get smaller, quickly. But the inside of the dish next to the pudding cannot cool so quickly because it is next to the hot pudding. With one surface of the dish quickly contracting and the other still expanded, no wonder the dish cracks.

The sun can heat rocks so that they will expand just as a heated dish does. When evening comes, the top part of a rock cools quickly. If it gets smaller before the mass of rock underneath contracts, the outer layer of rock may crack. The pieces of the rock that break off in this way also become part of the soil.

Chemicals in Water May Dissolve Rocks. As rain water flows through the ground, chemicals dissolve in it. Carbon dioxide from the air also makes a weak acid when it gets into the water. Water with chemicals in it can dissolve some parts of rocks as it runs over them. After these pieces are carried away, the rock that is left may crumble into tiny pieces and become soil.

The chemist can tell you much more about what goes on when soil water acts on rocks. He will explain by drawing pictures of the molecules of the rocks, of carbon dioxide, and of water. In some places chemical changes like the one between baking soda and vinegar, mentioned early in this book, have occurred. Then new kinds of molecules have formed. In other places the molecules of rock and soil that dissolve find space between the molecules of water and become invisible. This is the same thing that happens when you stir sugar in water.

Some of this dissolved material can be carried far away and become soil again after the water that contains it evaporates.

Glaciers Are Soil-Makers. During past centuries slow-moving glaciers have also helped in making soil. As they creep along they crush and grind rocks and pebbles that are under them and push others ahead of them. These great sheets of ice that form in the Far North and Far South, and travel just a few inches in a whole year, play an important part in making soil.

Many glaciers plow up trees and layers of soil as they slide along. Soil and rock material may also be found on the top of a glacier.

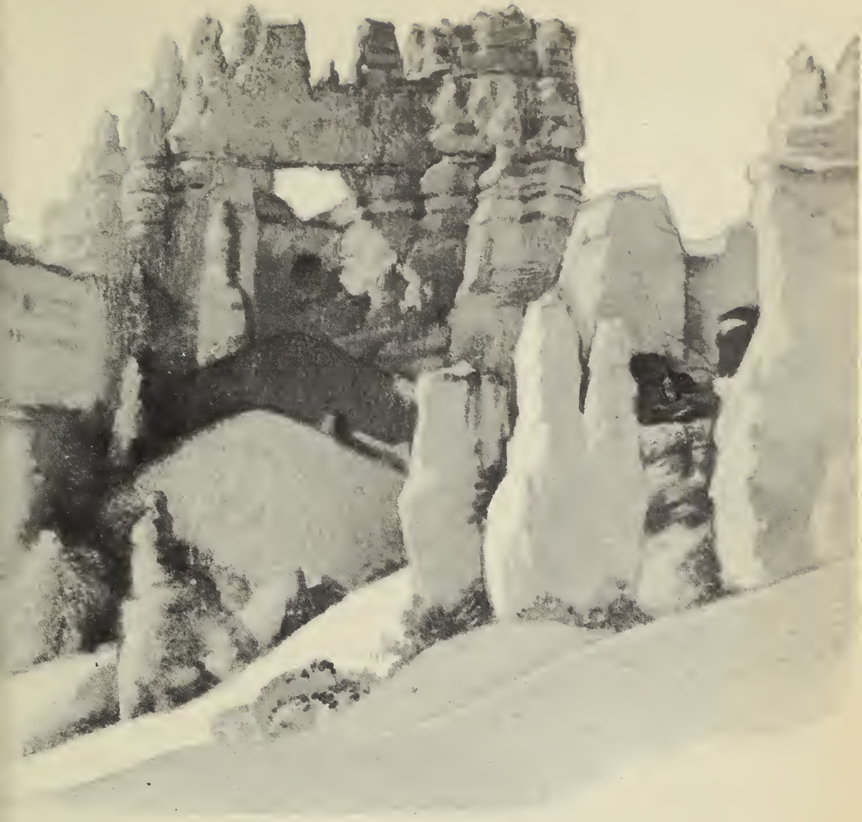
When a glacier reaches a warm climate and some of the ice melts, the pebbles and big rocks will drop out of the melting ice. Some of these will be washed along with the streams, while others will become part of the soil in the places where they are dropped. In this way glaciers help to make soil.

Since glaciers do not cover as much of the world's surface as they did long ago, they are not important soil-makers today. They do not drop as large quantities of topsoil as they once did, to replace the soil that rivers carry away.

Water and Wind Scatter Soil

Many broken pieces of rock are carried by rivers to the ocean. But in flood times, as the water spreads out over the land, it drops its load of rocks on the banks of the river.

Before it flows into the Gulf of Mexico, the Mississippi River deposits rich soil which forms a large delta. Year after year the Nile River also gives its banks a bath of mud. It supplies the farmers with some of the richest soil in the world. So moving water sometimes helps to make soil.



Imagine the wind blowing by the rocks that are shown in the picture above. Pieces of sand carried by the moving air beat against the rock and grind it away just as sandpaper would. Sand has carved rocks in many places on the earth. Do you think the wind plays a part in soil-making?

Volcanoes Bring New Soil

Volcanoes are changing the soil in certain localities. Melted rock, or lava, may flow out in streams miles in length from a hole in the surface of the earth, or it may pour out in sheets and spread over many square miles of earth, forming lava fields. Pieces of solid rock and ashes come forth, too. The rock and ashes are added to the soil in volcanic areas.

A New Volcano. In February, 1943, a volcano began to erupt in a cornfield in Mexico. The volcano was named Paricutin, because that was the name of the near-by village. Tons of rocks came out of Paricutin each minute of the day for many months.

Lava from the volcano poured over the land for many miles around. It made a black carpet that killed the life under it. Ashes blew even farther away, changing the soil as far away as thirty-five miles.

Soil near Old Volcanoes. After a while these rocks will break into smaller pieces and become part of the soil. A very long period must pass before the new minerals will refresh the soil and the land can be used again for crops. However, rich crops of corn, sugar, bananas, and coffee now grow near the old volcanoes of the world. Vineyards cover some of their slopes. You can see that volcanoes work slowly in enriching the soil.

Plants and New Soil

Plants often break rocks into pieces. The small plants that grow on the surface of rocks and give off an acid help to make the rock crumble.

Have you seen tree roots that have pushed their way through rocks? As they grow, roots can break rocks apart. Also seeds sometimes fall between the cracks in rocks. If they can get enough light and moisture and grow large enough, they too can push rocks apart. This is another way that pieces of rock become new soil.

Plants help to make soil in still another way. When you hold soil in your hand and examine it carefully, what do you find? Soil contains more than just broken rock. Plants are part of the soil. They add their dead leaves, their roots, and their stems to it. All the plants that are left in the soil become part of it again.

The dead bodies of animals become part of the soil, too. When you walk in the forest or in a park again, notice the animal and plant life that is becoming part of the soil.

Length of Time Required to Make Soil

Crumbling rocks and dead plants and animals build the soil. Glaciers, volcanoes, wind, sand, and waves tear the rocks apart to make soil. Frozen water, hot and cold air, and chemicals crack rocks, and break them into the tiny pieces that add to the blanket of soil covering the earth. New soil is always being piled on old soil.

How long does it take to build one inch of soil? If you answer ten years or ten hours you may be right, because soil is sometimes made very quickly. If you answer ten million years you may be right, too. Most soil on the earth has formed very slowly.

For millions of years new soil has been forming. Some has been pressed into rock again, and some has been washed into the ocean. At the same time that soil is being formed, it is also being used and worn away. Soil is always changing and moving.

During the period of soil formation a thick blanket of soil was held on the earth by a mass of living and

dead animals and plants. Dead plants were packed back into the soil where they had grown. They returned the chemicals which they had used and made the earth spongy like the humus of the forest. And, like a sponge, this soil held the water which fell as rain. Root systems interlaced and clasped the soil, holding it in place. When winds blew across the forests and fields, plants were anchors for the soil.

Gradually part of the soil was carried away by rushing water and sweeping wind. But new soil was being made to take the place of the lost soil.

How the Soil Was Changed

Cutting Forests and Plowing Land Changed the Soil. When people first farmed the United States, they had an average of nine inches of fertile topsoil in which to plant their crops. In the East, men plowed and planted year after year in the changing soil. Hilly forests were cut, and crops took the place of the trees. But the roots of crops could not hold the soil as well as the tangled roots of old trees and other plants which had once covered the ground. Topsoil rolled down the hillsides. From hundreds of sloping fields, soil was carried away during each rainfall.

For many years there was plenty of land with topsoil. When too much soil had washed off their fields, farmers moved on to a new place where the soil was still thick. As more people came to America, farmers spread out over the land. When food would not grow in the thin, rocky soil, many families moved toward the West and others left farms for the cities.

As they pushed westward, the pioneers found forests covering the new land. These were chopped down to clear the fields for planting. Gradually the topsoil in these regions was washed away. Then men again moved to new land that seemed endless.

One-Crop Farms Used Topsoil. Some plants give the wind a chance to sweep away the soil. When plants are set far apart, there are fewer roots to hold back the water. Such plants as cotton, corn, and tobacco do not protect the soil from driving winds

and rains. They do not grow closely together; so water carries more soil from between the rows of these plants than it does from other fields.

Some crops also take more minerals from the soil than others do. Have you watched the ash grow at the end of a burning cigar? All the ash and some of the smoke are made from materials which the tobacco plant takes from the soil. The tobacco plants rob the fields of certain minerals.

In many places farmers planted the same crop season after season. Year after year men and mules plowed Southern fields for cotton, corn, and tobacco planting. Down the Mississippi went millions of bales of cotton. Cotton from the South went to fill the spinning wheels of England. Cotton and tobacco for the people of all the countries of Europe grew in Southern soil. Cotton and tobacco took minerals from the soil, and left it worn and bare. Just so the gently rolling lands of the Mississippi Valley lost much of the richness in their topsoil.

In other parts of the United States, farmers made the same mistake. Some planted corn and some planted wheat; but they planted the same crop again and again. Many of their fields became worn out. They became wastelands which could no longer supply the materials that the plants needed. Some farmers added fertilizers to help to improve the soil; others left the poor lands and moved on to the West.

Dripping Water from Homes and Barns Loosened Soil. Here and there dripping water from a rainspout or a slanting roof hits the ground and moves some of the soil beneath it. In a town in Missouri, bare roots of an oak tree stand high above the soil. Rain water which dripped from the eaves of a near-by

house carried soil from around its roots. After many years a ten-foot layer of soil had been washed away by the streaming water.

On a farm in Georgia, water dripped from the roof of a barn at each rainfall and pushed the soil away. Gradually a gully formed, which grew longer and larger as water cut deeper into the soil. As little streams of water bit through more of the earth, the gully spread across a highway and through several farms. Finally houses caved in, a school was destroyed, and a graveyard was swallowed by the gully.

When rain water races over bare lands, gullies form. Look for small gullies on tiny slopes after a rain. In many places they are spreading deeper and wider. New ones form on the sides of an old gully and leave great gashes in the bare land. Some are deep, with sides that are almost vertical. Think how much soil has been washed away.

Dust Storms Carried the Soil Away. West of the Mississippi the topsoil was destroyed in a different way. Level, grassy plains stretched west of the Mississippi River when the first farmers went there. Large herds of buffalo roamed about. In summer grass that grew waist high covered the plains. Some of the first men who saw these lands believed that all the flocks and herds in the country could find food on these pastures. Soon cattle and sheep began to be raised on the western ranges. They roamed the plains, eating grass and digging their hoofs deep into the soil.

More people invested money in the cattle, which supplied most of the meat of North America. More animals were turned loose to graze on the grass, which was eaten faster than it could grow. Plants were nipped so close to the ground that they could not grow again. More hoofs pounded loose soil into powder, and good grazing lands became bare soil.

On other parts of the Great Plains, farmers raised wheat and corn. New machines ripped up the soil faster and faster. One-crop farms, like those of cotton and tobacco, gradually became poor farms as the land wore out. Dry seasons came, and tender plants shriveled and died under the hot sun. Here, too, bare soil lay loose on the ground.

In twenty thousand years wind and water will remove about seven inches of soil where blue grass grows. When the land is made bare, it takes only twenty-one years to remove seven inches of soil.

Blizzardlike dust storms swept over the lands made bare by too many animals and too few plants. In wet years farmers were able to grow some crops on the land, but there were too many dry years to keep the plant life alive.

The summer of 1934 was a dry summer. Strong

winds swept across the country from the west. Clouds of dust blew east. One wind storm followed another until a part of the Great Plains became known as the Dust Bowl.

During some of these dust storms, the sun's light was darkened by black clouds of dust. Children covered their faces as they walked home from school to keep the grains of soil from stinging their skin. Mothers stuffed rags in the cracks of doors and windows, but still the fine dust came in. Animals got dust in their mouths and in their lungs. Fences were buried, and dust piled against the sides of houses as high as the eaves, as the wind scooped up the powdery earth and carried away tons of soil.

After the wind had whirled tons of soil into the air and swept the tops from the fields, many farmers were completely discouraged. But others talked to

scientists about the best methods of reclaiming the farms of the Dust Bowl. Because of the courageous work of these farmers, the Dust Bowl has become millions of acres smaller. As you read farther, you will learn about some of the better methods of plowing and planting and other new ideas that have enabled farmers to save the soil, not only in the Dust Bowl but in other parts of our country as well.

Ways to Save the Soil

Grass Can Hold the Soil. One of the most successful ways to prevent the loss of soil by high winds is to plant grass that has many strong roots. This method proved successful in the lovely old town of Provincetown on Cape Cod in Massachusetts, about one hundred and twenty-five years ago. Strong winds had swept across the Cape and picked up sand.

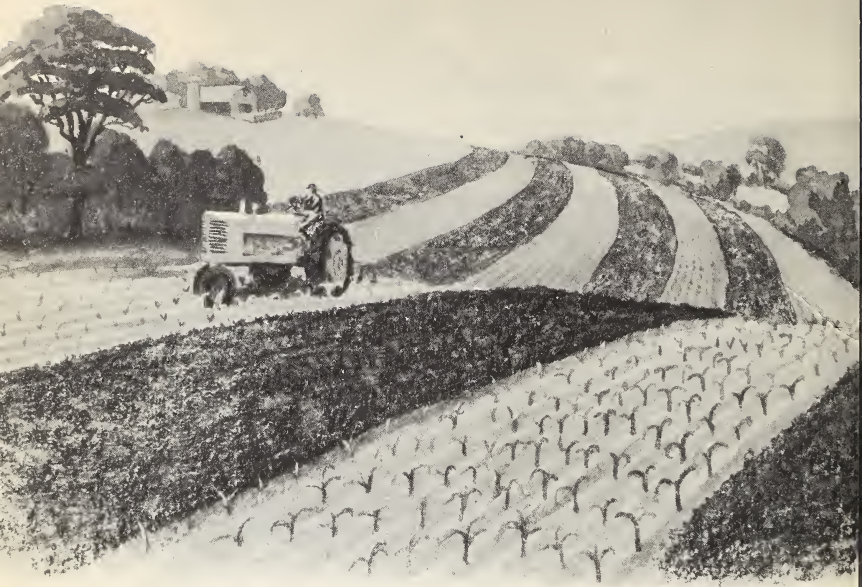
Along the shore huge sections of beach had been washed and blown away.

The people in the town found a special grass that had many large, strong roots. They planted this grass along the hills of sandy soil. The great roots grew deep and held down the soil so that neither winds nor waves could sweep it away. Laws were made to keep animals from roaming through the grass and using it for food. The grass grew tall and kept Provincetown from being blown and washed into the ocean.

Today grass is still being planted along our shores to keep them from being washed into the sea.

Roots to Hold the Soil on Farms. Other people have found grass a good cover for the soil. Each grass plant has many little roots that anchor it. When rain falls on grassy plains, much of the water soaks into the spongy soil. Instead of running off grassy hillsides and taking soil with it, the rain finds its way into the soil through the mat of roots.

Scientists have also experimented with other plants. They have found that clover, alfalfa, and grains have roots that grasp the soil and push it apart in such a way that water can easily seep into it. They advised the planting of trees, too, because trees cover the ground so that raindrops strike



more gently. Perhaps you have watched water as it runs over bare land on a rainy day. The water carries more soil than water on a forest floor, which is covered with twigs and matted leaves.

Crops Can Be Planted in Strips. Although deep-rooted cover crops such as grass and clover hold the soil, they do not help to feed and clothe the world. So scientists worked until they found a better way to grow corn, beans, and cotton. To slow down the running water they plant a strip of land in clover, then a strip in corn, then another in clover. Soil washed from a corn strip is caught by the clover. Less soil is lost from farm land when it is caught in this way by the thick growth of plants.

Modern farmers avoid the type of farming called the one-crop system. They have found that by not planting year after year crops that take the minerals out of the soil and do not put them back, the soil can be enriched. Bacteria on the roots of alfalfa, clover, and similar plants put back into the soil part of the minerals that they have taken from it. These chemicals are stored in the ground and used by the next crop.

Since corn, cotton, potatoes, and tobacco take more minerals from the soil than some other crops do, the order of the strips is changed at each planting. For example, alfalfa is sown where corn grew the season before. Rows of corn fill the strip where alfalfa grew.

Plowing around the Hills. Scientists have found other ways of saving the topsoil. Farmers used to plant seeds in rows that ran from the top to the bottom of a slope. The furrows made gutters for the water that fell on a field during a rain. The rows across the slope make many little dams that hold the rainfall until most of it can sink into the soil. The rain can no longer carry seeds and soil with it.

Plowing rows around hills instead of up them is called contour plowing. Farmers who plant in this way save their topsoil. Field after field of even, curved strips can be seen as one flies across the United States. The different colors of the rows make a pattern on the ground. When you see these patterns from the train or plane, you can be sure that the farmer working there is saving the soil by contour plowing.

Terracing. Terraces help to save soil, too. These sloping steps on the sides of a hill are made to hold back water. They may be stone walls built in the soil, or just piles of dirt. On hills that are not too steep, farmers make terraces of soil as they plow the field. Crops grow on the level parts of the terrace.

More Ways to Hold the Soil. Many gullies have such bare steep sides that nothing will grow on them. Without roots to hold the soil, the gullies cut deeper into the land. Little dams made of brush can be built across these gullies to check the flow of water that follows a rain. Then plants on the sides of the gully will have a better chance to grow and hold the soil.

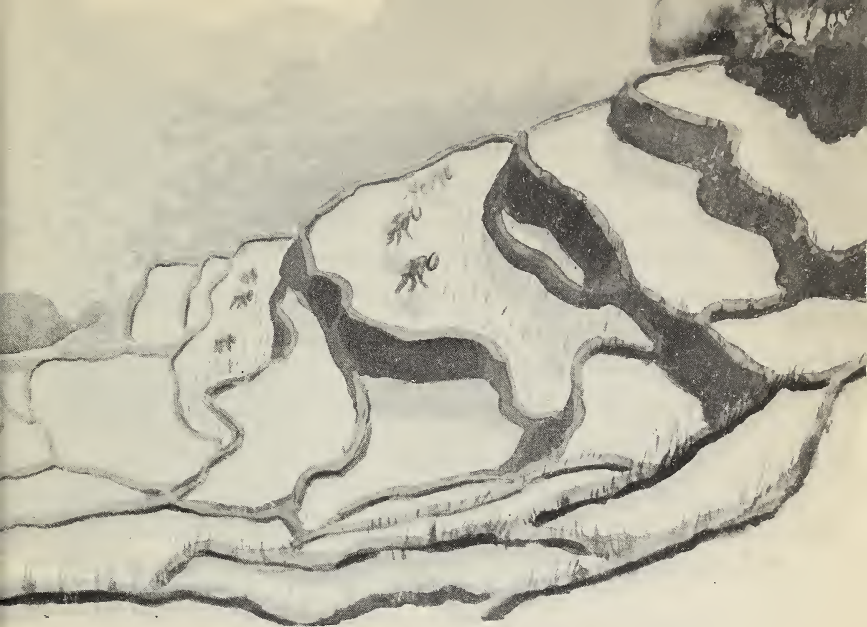
The plants shown in the picture barely cover the soil. Soon they will make a thick carpet and protect the bare, dusty ground from wind and water.

Man Is Working to Save the Soil

The old frontier days when rich soil was plentiful are over. Today the saving of topsoil is a problem that everybody must help to solve. Poor soil means poor food and poor people. People in the United States can no longer afford to plow and plant until the soil is worn out.

For a long time soil has been washing from the land much faster than it has been forming. Now we must do everything we can to save the soil and to enrich it.

Scattered over the United States are 100 million acres of farmland which have become wasteland. If this wasteland were stretched out in one big farm, it would take up as much space as the State of California. Other pieces of land that would make an



area equally large have been seriously damaged by loss of topsoil. Can the damage be repaired?

In China farmers have changed poor land which supported less than 150,000 people to terraced cropland which feeds about 45 million people.

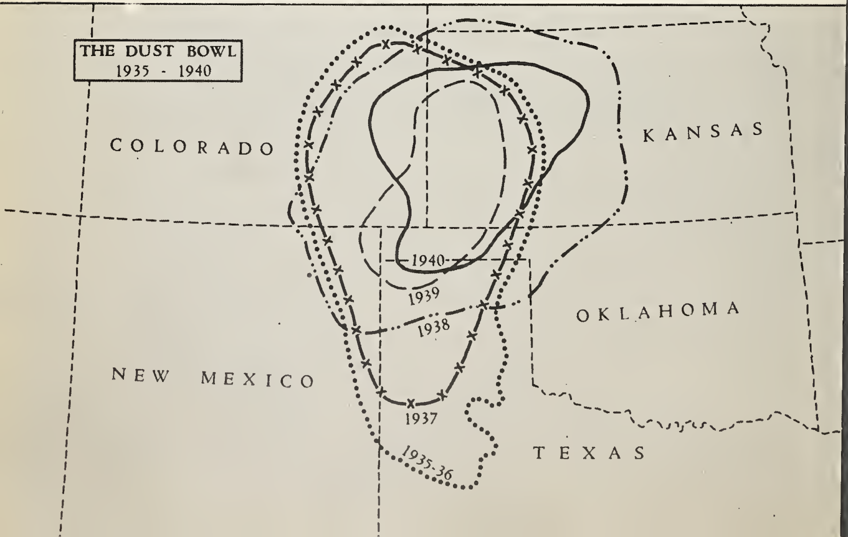
In the United States, the Dust Bowl has grown millions of acres smaller. The government, scientists, and farmers are working with nature to save the soil. Many farmers have learned that thoughtful farming means better land for future use. It means bigger and richer food crops, too. Scientific farming will bring about better living for people, no matter where they live. In addition to helping to feed and clothe the nation, farms are supplying materials for new industries. Chemists have developed new ways of using farm products. Materials that can take the place of glass, metals, and gems are being made from corncobs, peanuts, straw, soybeans, and other plants that grow in the soil.

We certainly need to keep our soil in good condition. Can you help to keep the topsoil in its place on the land?

WHAT DO YOU THINK?

1. On the map below notice how the shape of the Dust Bowl has changed since 1935. Can you tell why?

2. Some farmers hold topsoil on the land by using a machine which makes the pattern of a waffle over



their fields as it plows. Little dams of earth are thrown across each furrow. What happens to the water where this kind of plowing has been done?

MORE THINGS TO DO

1. Imagine 1000 freight cars each filled with 40 tons of earth traveling to the ocean and emptying their load of soil into the sea. The Mississippi River carries as much soil as this with it every hour. Can you tell how much soil is carried away in one day? How much topsoil is washed by the Mississippi River into the Gulf of Mexico each year?

2. Make some soil by grinding rocks together.

3. Collect samples of soil. Examine them to see if you can tell from what the soil is made.

4. Look for places that are losing their topsoil. You may find them in your schoolyard, your garden, a park, or a vacant field. Suggest a way to hold this topsoil in its place.

5. Take a walk in the woods or in a park to look for leaves, twigs, or other things that are becoming part of the soil.

6. Find in rocks cracks that may have been caused by sudden changes in temperature.

7. Show your class a place where roots of a tree have broken rocks or cracked pavement.

Sound Ideas about Health

Your Health and You

Somewhere in almost every chapter of this book you will find facts that concern you very much. The molecules around you, friction, the soil, light and sound, all affect you. None are more important than the sound ideas that scientists have given us about health. Ideas that have been proved helpful through the experiments of scientists are sound.

Your Skin Is a Protective Coating

From head to toe you are covered with skin. The area of skin that covers your body is probably equal to that of a rug three feet long and two feet wide. We have been told this by scientists who can measure a person's skin in somewhat the way the area of a lawn is measured by running a lawn mower over it. If you count the number of strips made by

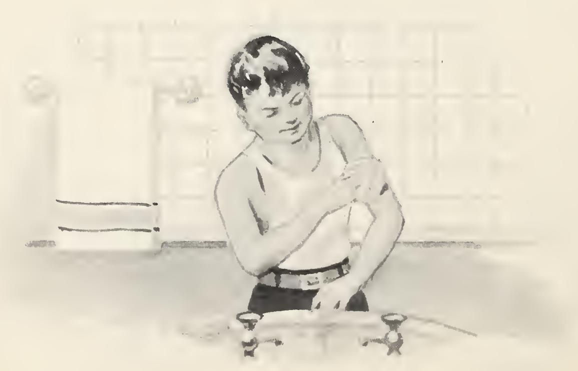
the mower, and if you know how wide each strip is, you can find the size of the lawn. A "skin-roller" operates on the body in a similar way.

Our coating of skin serves as a protection to the whole body. Even though it is full of tiny holes, called pores, the skin is tough enough to protect the delicate inner parts of the body. An oily substance which covers the skin makes it nearly waterproof. The perspiration that comes through the pores in the skin helps to keep the skin clear and the body healthy.

Small amounts of the outer skin wash off when we bathe. Of course you need not worry about washing any old skin off; for new skin is always growing to take the place of the skin you lose.

Dirt and germs that cause diseases cannot get through your protective coating of skin. But a coating of dirt is no protection to you. Dirt and disease seem to go together.

Many scientists believe that clean skin helps to



do more than ward off harmful germs. Suppose you have washed one hand and the other hand is very dirty and that someone pours the same number of bacteria on each hand. If you could count the bacteria ten minutes later, you would probably find more bacteria on your dirty hand than on your clean one. Such experiments have shown that clean skin has the power to destroy certain kinds of bacteria.

Germs cannot get through your skin unless it is broken, but they can go along with your fingers when you put them into your mouth and they can get into your body on food that you have touched with soiled hands.

Colds Are Contagious

Doctors believe that colds are caused by tiny bodies called viruses. Viruses that cause colds are on your skin much of the time. They do not travel through your skin into your body, but from one person who has a cold to another person. Viruses get into your body through your mouth and nose, too.

How Colds Spread. Think what happens when a sneeze is not caught in a handkerchief! Droplets from a sneeze can travel across a large room through the air. With these droplets, travel cold viruses.

If someone comes to school with a cold, stay away from him if you do not want to be infected by the viruses. If you have a cold, stay away from school. Do not give your cold to another person by sneezing and coughing. Protect others by using a handkerchief.

Treating Colds. If you stay at home when you have a cold, your friends will think well of you, because they know that you are helping to protect them from a cold virus. Rest at home should make you feel better, too. When you catch cold, you do not know what will come of it. A cold may go away in a short time or it may stay and stay. Your body has to work harder when you are sick. A bad cold may make your body become so tired that other diseases can get a start.

Not all doctors agree about ways to take care of a cold, but they are certain that the following things help people to get better. They agree that a person who has a cold should rest in bed, drink plenty of water, and drink as much fruit juice as possible.

Scientists are trying hard to find ways of preventing colds, because they cause illness among so many people all over the world.

How to Avoid Infection from Hookworms

Another disease which affects many people is caused by hookworms. Hookworms are small round worms which can bore through the skin. They live on the ground in the southern part of the United States. If a person steps on young hookworms when barefoot, they may crawl between the toes and work their way through the skin. Hookworms look somewhat like a small white thread about one twenty-fifth of an inch long. The hookworms in the picture on page 332 have been magnified many times.

After young hookworms bore through the skin, they can get into a person's blood and travel to his

heart. Then they can go to his lungs, then into his windpipe, and finally into his intestines. There they feed and multiply.

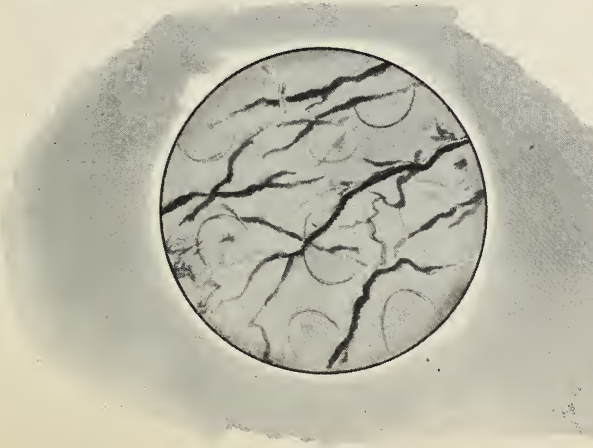
Scientists believe that more than two million people in the United States are feeding hookworms as well as their own bodies. Most of these people do not feel as well as they might. A child with hookworms will not grow as fast as he should. He may appear to be only ten years old although he is really fifteen.

With proper treatment by a doctor, it is not very difficult to get rid of hookworms. And if a person always wears shoes when walking outdoors, he will never have hookworms, because they cannot crawl in between his toes.

Preventing Ringworm and Athlete's Foot

Another disease which infects many is called ringworm. Ringworm is not an animal and it cannot travel through the skin; it is not even a worm. It is a skin disease caused by a plant which is so small that it cannot be seen without a microscope. Ringworm is difficult to cure without the doctor's help.

A common skin disease of the feet that is much like ringworm is called athlete's foot. Around swimming pools and in gymnasiums where people walk barefoot, athlete's foot spreads from one bare foot to another. When the plants which cause this disease make their home on a person's feet, they grow between the toes and make that part of the foot itch and burn. The skin cracks and peels, too. If you ever have athlete's foot, ask your doctor to help you to get rid of it. He will tell you what to use in the water when you bathe your feet.



Plants which cause ringworm

First Aid for Wounds

An open place in your skin, like a cut or a broken blister, is a door through which germs can get to the inside of your body. No matter how small a scratch or a cut may be, it is always large enough for thousands of germs to enter.

We are usually healthy enough not to have trouble from small scratches and cuts, but sometimes they become red and sore. They will not heal quickly if they are infected. Now and then a very bad infection, called blood poisoning, gets in through a break in the skin and spreads throughout the body.

There are substances in your blood that are able to destroy germs unless there are too many of them. Sometimes germs grow very fast. Since you cannot see them and do not know what kind they are, you cannot tell what will happen. Any opening in your skin, no matter how small, should be taken care of at once. Do not give an infection a chance to spread.

You can get rid of many germs by washing a cut with clean cotton or gauze that has been moistened with alcohol. Begin at the center and wash the dirt out of the opening, not deeper into it. If the wound is not near your eye, put a little fresh iodine on it and around it.

Tincture of iodine is iodine that has been dissolved in alcohol. Most doctors suggest that you use a tincture of iodine that is about 98 per cent alcohol. The bottle should be kept tightly closed. If the alcohol is allowed to evaporate, the solution will become so strong that it will burn the skin.

Clean cotton wrapped around the end of a toothpick is an easy and safe means of putting iodine on a cut or a scratch. You should never pour iodine into a wound.

Since germs are usually on our hands, do not touch an opening in the skin with your hands. After the iodine is dry, cover the wound loosely. Be sure that the cloth you use is very clean. The sterilized bandages that can be bought at a drugstore are free from germs. If you have no sterilized bandages, use a strip of freshly ironed linen. Do you know why only clean bandages should be used to cover an opening in the skin?

When you treat a cut or a scratch at once, infection does not have a chance to start. For that reason a treated wound heals more quickly than a neglected one.

All of us get splinters under our skin at some time. If a splinter is not too far under the surface of your skin, remove it with tweezers or a needle that has been held in alcohol for several minutes. Or hold the needle or tweezers in a flame to kill the germs on it. When it has cooled, remove the splinter with it, and make the wound bleed a little to wash out any germs that have got inside. After the bleeding has stopped, treat the opening in the same way that you would treat a cut.

If a splinter is buried deeply under the skin, paint the opening with iodine and ask a doctor to take the splinter out.

Taking Care of Burns

Even though your skin is a rather tough covering for your body, it does not seem tough when something very hot touches you. Do you know how to take care of a burn?

Perhaps you have learned to use butter on a burn. Any grease, such as butter or vaseline, or a medicine for burns will help if the skin is not broken. Only bandages that are sterile should be placed on open wounds in the skin.

If a person is badly burned, use baking soda instead of grease, but call a doctor at once. Baking soda may be used for minor burns, too.

Has the sun ever burned you enough to redden your skin? Sunburn should be treated in much the same way as other burns. Sometimes to prevent your skin from burning, it helps to put olive oil or

cocoa butter on your skin before sitting in the summer sun. Of course it is better to let the sun warm your skin a bit each day. If you begin by staying in the sunshine a short while, your skin will gradually become accustomed to the heat, and you will tan a little at a time and not suffer from sunburn.

Treatment for Frostbite

In winter your skin is often chapped. Perhaps you have heard someone who has been out of doors for a long time say, "My nose is so cold that it must be frozen." He may be right about the condition of his nose. In the cells of a person's skin, there is water. This water can freeze. When it freezes, the ice pushes against the walls of the cells and injures the skin.

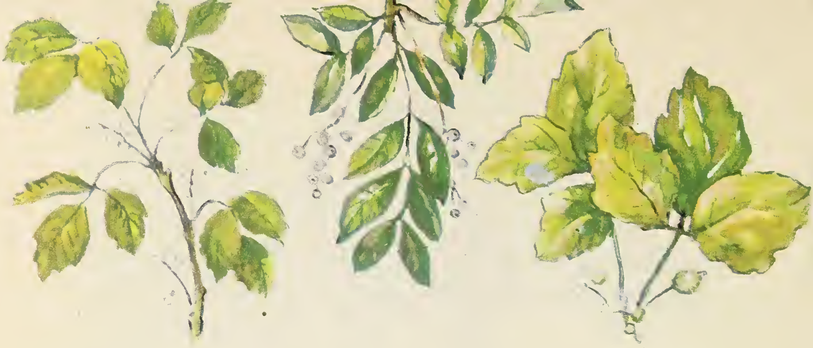
Most cold noses are red, but a frozen nose is grayish white. Other parts of your body, for example, ears, hands, and feet, may become frozen, too. Usually frostbite is very painful.

Arctic explorers have taught us that frozen skin should not be rubbed. Many people thought rubbing would help, because it warmed the skin. Rubbing with snow does not help either. The hard, frozen water is then pushed from one place to another and the skin is injured.

Hold the frozen nose or foot with your hand so that it will thaw gradually. Put a frozen hand under your arm until the frozen cells melt. Warm water and radiators will make them melt too fast. With careful treatment your skin will soon feel as usual.

How to Care for Skin Poisoning

Rubbing is poor treatment for skin that has been in contact with plants that cause skin poisoning. The poison may get on your hands and be carried to other parts of your body. If your skin is red and swollen from poison ivy, poison oak, or poison sumac, wash it with soap and water. Then cover the poisoned place with a paste made from soap and a little water. Keep this soap on your skin all night.



Poison-ivy lotions may help to make you feel better, too. After dissolving as much Epsom salts as you can in a quart of cold water, bathe the poisoned part of your skin with this solution.

The best way to avoid skin poisoning from plants is to know which plants cause it, and stay away from them. Poison ivy and poison oak are climbing or spreading plants that grow in woodlands and along fences and stone walls. Their leaves are rather broad and grow in groups of three. Poison oak looks much like poison ivy, but the edges of its leaves are more deeply notched than those of the poison-ivy plant. Poison sumac is a shrub or a tree which may grow as high as twenty feet. It has loose dropping clusters of white berries. Remember, there are many kinds of sumac that are not poisonous.

When the oil which these three kinds of plants produce gets on skin, it may cause severe poisoning. Sometimes people suffer from poisoning even though they do not touch these plants. Insects, clothing, or the smoke of burning leaves may have carried the oil to their skin.

If you have been near a plant that can cause skin poisoning, wash your skin with soap as soon as you possibly can. Then rinse your skin with clear water and dry it. This may prevent the blisters and the itching which result from skin poisoning.

If you have suffered from skin poisoning, you know why people say, "Leaflets three, let it be." Avoiding poison plants is as important as curing the infection.

More First Aid

If you are a scout, you have probably learned how to give first aid when there is an accident or sudden illness. Perhaps someone in your class has a junior first-aid certificate. Before a person can hold such a certificate, he must study many ways of helping people who have become suddenly ill. He must know what to do when there is an accident.

One of the most important things which a first-aider must know is what "first aid" means. Probably the first thing you learned was that you are to give first aid only until the services of a doctor can be obtained. Then your duties end, because the doctor, who has studied for many more years than

anyone with a first-aid certificate has, will take care of the patient.

The things that you can safely do when someone becomes suddenly ill or when there is an accident are given below. Study these rules of first aid so that you can help if you are needed.

Call a doctor and tell him where the patient is.

Keep the patient lying down.

If a person is not breathing, find someone who knows how to make the patient breathe.

Keep the patient warm. If there is no blanket or coat near by, use newspapers.

Keep crowds away from an injured or sick person. Stay away yourself if you are not needed.

MORE THINGS TO DO

1. Ask your school nurse to show you how to wrap bandages around your hand and foot.

2. Ask a scout to show you how to treat a person who has just been rescued from drowning.

3. Look in the medicine closet in your home. Find out if you have the things that are needed for first aid. Try to get those that are missing.

WHAT DO YOU THINK?

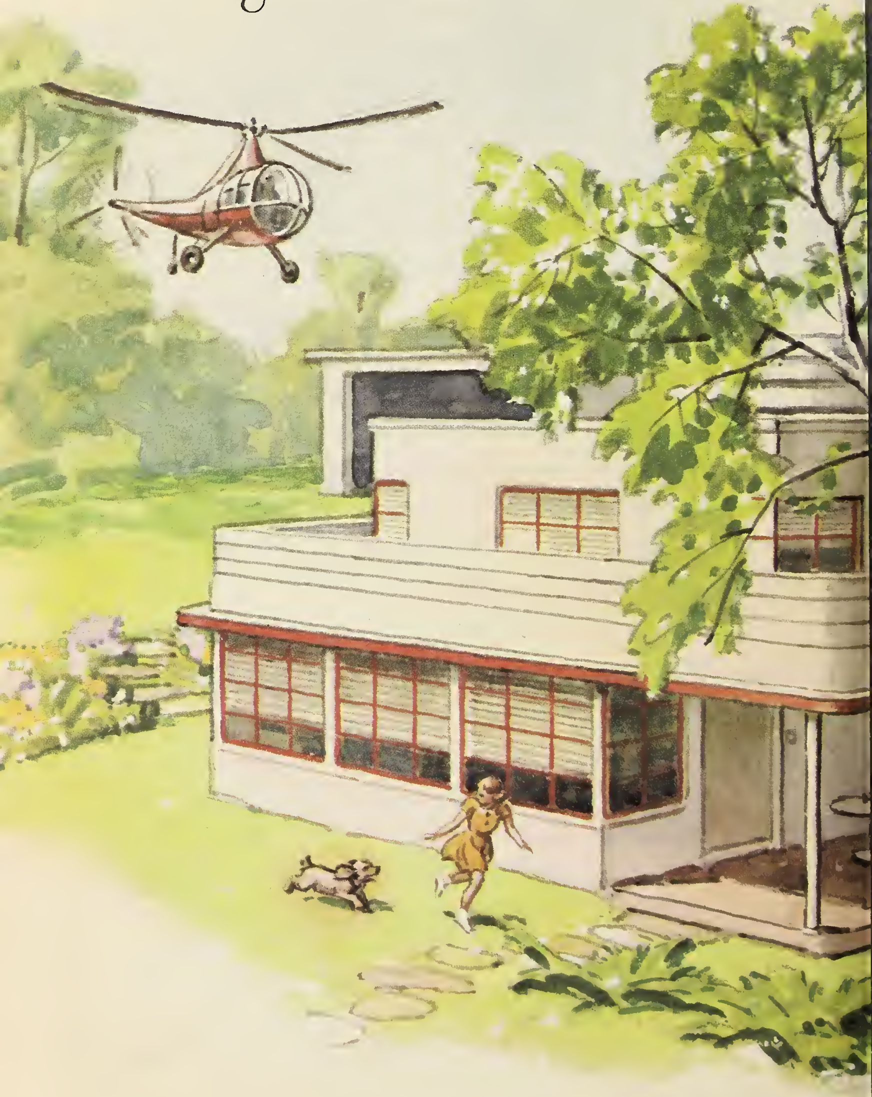
1. Is there anything that you can do to prevent colds?

2. From your own experience list three ways of catching cold.

3. List three or more simple health rules that every boy and girl should follow.

4. Do you put your fingers in your mouth? Keep a record of the number of times your hands are in your mouth in one day.

Using New Ideas

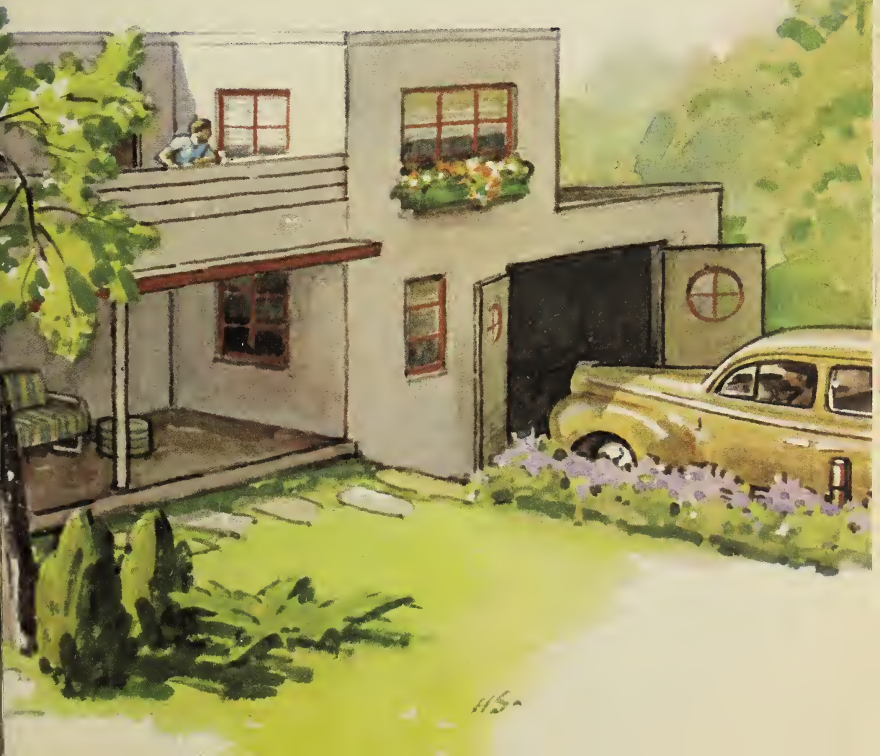


Using New Ideas

Let us read the title of this chapter aloud.

Before you read farther into this chapter, can you recall when you last tried out a new idea?

A class became interested in hiking and decided to go on a trip. Because the boys and girls in the class had discovered many new ideas about foods, they knew what food and equipment they should take with them. They had found out in their laboratory work that certain foods give them energy



and that others build their bodies. On the bulletin boards of their room were graphs made with strips of colored paper showing the amounts of vitamins, minerals, proteins, and other important elements found in various foods. From the scientific knowledge that they had gained in this school work, they could prepare for their trip.

New ideas can come to you from many branches of learning if you are on the alert. One class enjoyed a visit to a great play in a large city. This experience was so thrilling that it gave the class new ideas about assembly programs, and a new club also resulted. Has your class tried out a new idea this year about how to study? Have you formed a club based on a new idea? or written a new play for your assembly? or held a contest in snow sculpturing, or gardening, such as you have never held before?

New Ideas of Americans and Others

New ideas are being put into use each day. We Americans can be proud of our men who have had new ideas in various fields. Franklin had a new idea about electricity; Davenport used it in his electric motor. Franklin also had a new idea about the way storms move across our country. Other Americans used this idea to form a weather bureau to tell all of us, but especially farmers and sailors, and now airplane pilots, what the weather conditions will be a day, two days, or a week from now.

You have heard of the new ideas of Eli Whitney, George Washington Carver, Luther Burbank, Charles Goodyear, to mention only a few whose names have not appeared before in these pages. This chapter could not be made long enough to mention all the Americans who have given us new ideas in science, yet we are still in need of many new ideas that will help make life better for many people.

The new ideas that these scientists have given to us did not come to them suddenly. Each of these men worked many years on one experiment before he perfected it for use by others. Carver's interests in plants began when he was a small boy. He learned then to observe plants closely and to gather information about them that was useful all his life.

Whitney

Burbank

Carver

Newton

Science knows no nationality or race. Nobel, a Swede, invented dynamite; Marconi, an Italian, gave us the radio; Newton, an Englishman, showed us the laws of the earth on which we live; Pasteur, a Frenchman, used ideas about disease never dreamed of before. Notice the names of men of science who have used new ideas for the betterment of humanity: Noguchi, Metchnikoff, Koch, Jeans, Becquerel, Oersted, Galileo, Curie. Do you know in what countries these people were born and what new ideas they gave us? An encyclopedia will give you information about them.

Americans have, of course, had new ideas on many subjects besides science. For example, our form of democracy was a new idea in government. Can you name some of the men who were not afraid to put into use this new form of democracy? Your history will give you their names.

Only Human Beings Have New Ideas

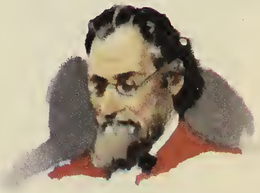
Only human beings can think of new ways of doing things. Sometimes they have been very slow in discovering and using these new ways. For example, man has been slow in learning how to improve the soil. Perhaps he would not have allowed it to be ruined in a few years if he had known how long it takes to make good soil. Man has often thought little of the future of the forests and has cut down trees in thoughtless, wasteful fashion. Yet, in spite of his ignorance, thoughtlessness, and wastefulness, man is the only creature who can discover and use new ideas.

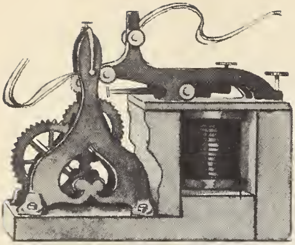
We human beings are using new ideas every day to protect life and property, to understand our fellow men better, to live in peace with ourselves and with our world. We do not have to be great scientists to put new ideas to good use. We

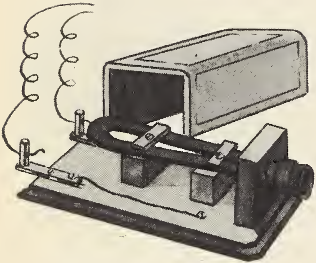
Pasteur

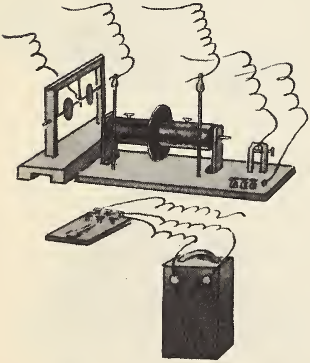
Marconi

Nobel


Metchnikoff


Morse's telegraph


Bell's telephone


Marconi's wireless

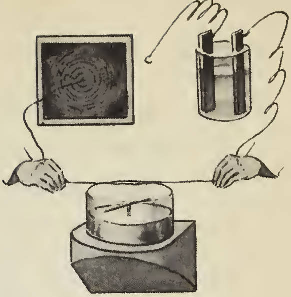
learn to use them because they are an improvement over older ideas or over ideas that never did work. All of us can disregard superstitions that have been handed down by ignorant people who lived long ago.

The Scientist and His New Ideas

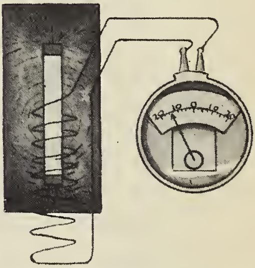
We can use the new ideas of scientists because they work carefully and do not announce their ideas until they have been tested. Scientists work painstakingly. They observe and record every step in their work. Even scientists, however, have been known to overlook what seemed to be happening right under their eyes. Later a more observant person has made a great discovery from the idea that the first scientists overlooked.

Here is a true story about a man who overlooked facts that might have given him a new idea. This man was interested in materials that give out a strange glow. He even studied the strange substance that makes the lightning bug glow. He noticed that whenever boxes of photographic film were kept in a certain stockroom where minerals were also kept the films became spoiled. But he simply said to himself, "That's too bad," and told his assistant to see that the films were not stored there again. If he had carefully observed what had happened to the films, he and not Becquerel would have discovered radio-activity, and he and not the Curies might have found radium.

Fortunately for the world such mistakes are not often made by scientists. Scientists usually are alert to make use of every opportunity that comes their way. Goodyear was ready to use the idea that came to him when his rubber and sulfur fell on top of his hot stove. From his observation of what happened on the stove, he learned to vulcanize rubber.



Oersted's experiment



Faraday's experiment

Goodyear's experiment

Galvani, Volta, Franklin, Oersted, Henry, Faraday, Ampère, Ohm, Edison, Bell, Morse, Marconi, Einstein, Steinmetz are the names of a few men who have used new ideas in electricity. And every field of science has such a list.

Newton once said, "If I have seen further, it was by standing on the shoulders of giants." He meant that by using the work of others he was able to go ahead with his great discoveries.

There was an Austrian priest, Gregor Mendel, who died without talking to the world about any of his experiments. Yet, years later, great men all over the world used his ideas to prove their own ideas, and to make new products. Huxley and Darwin in England, Burbank in the United States, and many others elsewhere used Mendel's ideas to help their fellow men. Do you know what important idea of Mendel's these men used?

Gathering Clippings about Science

Most people like to collect things. You may be collecting insignia or stamps or coins or rocks. There are some who like to collect clippings. They snip, snip, snip and paste, paste, paste. Then they close the book and forget what they have done. This is a good plan up to the part where they close the

book and forget about it. If such people would read the clippings and use what they read, they might put their efforts and information to good use for the benefit of others.

Perhaps the clippings are pictures of interesting people. Every time these famous folk are discussed, the person with the collection can introduce them in picture form to his friends.

Or perhaps the clippings have to do with science—with gardening or astronomy or airplanes or radio. Such collections of clippings can be like rain on a dried countryside. They can furnish ideas for new thoughts or new inventions, just as the rain furnishes new life to struggling plants. You might invent a new game using your clippings to furnish you the answers. Call your game Authors of New Ideas.

But there is a group of people who are afraid of new ideas. They say, "If grandfather didn't do it this way, we won't." Some boys and girls of a great city are killed in the city streets each year because there is no place for them to play. But people who are afraid of new ideas say, "No, I didn't have playgrounds when I was young, and I grew up. Why should the children nowadays have them?" Yes, there are people who do not use new ideas but fight them. They think that life is as it was when they were young. They have failed to observe how many changes have taken place around them every day and that these changes have made life different from what it was in the past.

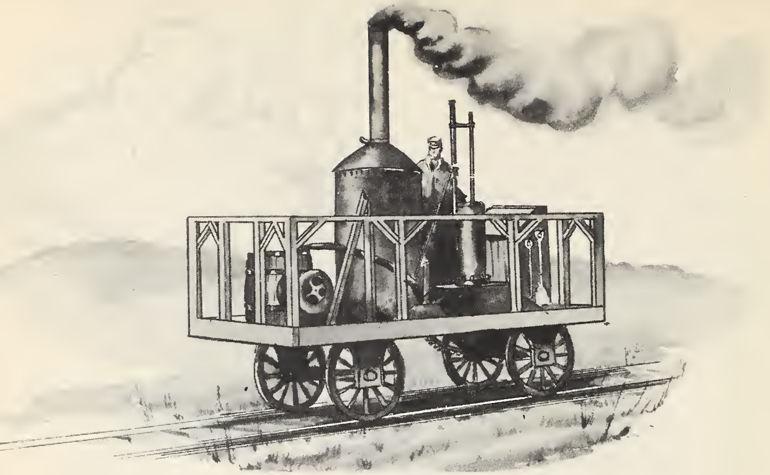
Newton admitted his debt to the past, but he used the past to make a happier future for all of us. That should be our attitude when we think of using new ideas.

Many of the ideas in this book may be new to you. Yet your parents have probably known about many of them for years. That idea about molecules was known to scientists before your father was born. But his grandfather before him did not know about those little "masses." And people who lived before that either did not attempt to find explanations for the many natural happenings or thought that they

Atom-smasher

could never be understood. Still others connected natural happenings with magic.

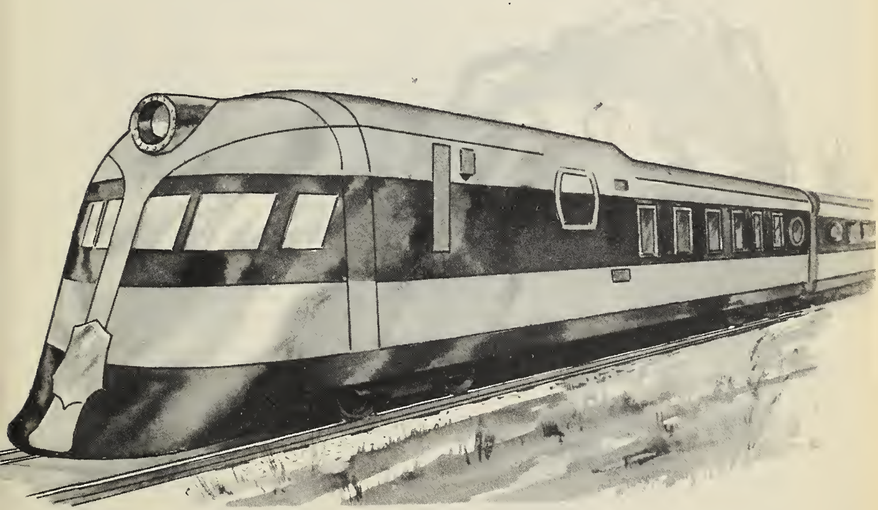
But you must remember that the idea of molecules has had many new ideas added to it as new facts about molecules have been discovered. We now know that those little particles are broken down into smaller units called atoms. About thirty years ago, the idea that matter contains unbelievably tiny units called electrons and protons was new. Today we know that these particles are about $\frac{1}{2000}$ the size of a molecule. You can't imagine anything so small; yet their existence has been proved.



Scientists have argued about the theory of light for more than a hundred years. Yet Einstein in the last forty years has given the world of science a completely new idea about the nature of light.

In electricity, sound, and means of travel, you can find new ideas at work that are causing changes in our way of living every day. In America new ideas have come fast and helped us to make many improvements in our inventions. The first electric light and the early carbon lamp have become the fluorescent lamp of the 1940's. The clumsy phonograph of 1877 and the automatic record-changer, with means of recording your own voice, are the first and the latest in a chain of new ideas. Look at the pictures of locomotives that have come into use throughout the years. Each change came about as a result of a new idea that was put to use. Your home is equipped with many conveniences that were not in your mother's home when she was your age. In medicine, health, safety, and many other fields of knowledge, you can think of many scientific ideas that have become usful to people since you were born.

Scientific facts may be new today, but old tomorrow. A new discovery, once it is proved, makes scientists change their ideas. People who are willing to change their ideas when new ideas are proved sound are like good scientists. If you are willing to change your mind after new proof has been given to you, then you are open-minded. You do not have to be a scientist to be able to accept a new idea.



Not All Old Ideas Are Worthless

There is one danger which everyone must watch out for when considering new ideas. To think that an idea is worthless because it is old is as bad a mistake as not being able to change one's ideas at all. Many old ideas in science are sound, and too important to throw away. In fact most new ideas are built, at least in part, on old ideas.

If an idea has been tested and it works, it is a good idea, no matter how long people have believed in it. Newton's laws of gravity, Galileo's findings about the heavens and the universe, the earliest maps and charts of the stars, are as true and reliable today as they have ever been.

New Ideas to You

Below are six ideas that you may have got from this book for the first time. Examine all of them carefully to see if you believe that they are sound. Could any of them ever become a superstition?

1. Our earth is composed of substances which may be elements, compounds, or mixtures. All substances differ from all other substances, because of the molecules that compose them and the way the molecules are composed.

2. Our earth is just a small part of a great universe, not yet completely measured. It is part of a family of planets and depends on the sun.

3. Life on the earth and in its oceans has changed from very simple to very advanced forms of life. All forms depend upon one another and, in turn, depend upon nonliving materials and conditions.

4. Friction plays an important part in our everyday living.

5. There are rules of health and safety that man must learn before he can be well.

6. Experience, experiment, and study produce ideas. More experiences, experiments, and study are our means of checking these ideas. Facts will produce the ideas that count, not guessing, hearsay, myth, daydreaming, or superstition.

These are a few of the ideas that this book has tried to bring you. Many of them were new to you. They can be used by you to find out new truths. Then you in your turn will give new ideas to your generation and find how the scientific way can work for the benefit of all people.

MORE THINGS TO DO

1. Begin compiling a dictionary of scientists, a kind of scrapbook of men and women who have used new ideas. What would you put in your dictionary about each scientist?

2. Show by drawings or clippings from magazines the way man has used new ideas (*a*) in the home, (*b*) in transportation, (*c*) in communication, (*d*) in pleasure, (*e*) in medicine, (*f*) at work.

3. Watch the newspapers for new ideas in science. Report to the class, telling them how the new idea may be used.

4. Play the game Consequences, showing how one new idea leads to another. Here is an example: Watt and his teakettle led to the modern steam engine. Can you fill in any of the steps between? Here is another example: Pasteur's trouble with beet sugar eventually produced the modern idea of germs. Do you know any of the steps between? Can you

find out about them? Read about men and their discoveries, and you will find other examples.

5. What are the superstitions illustrated in the picture on page 358?

WHAT DO YOU THINK?

1. Here are some old ideas about ideas. What do you think they mean? What do you think about them?

a. To work three, four, five times harder than anyone else; that is true genius.—Noguchi

b. Chance favors the mind that is prepared.—Pasteur

c. Changes are born in men's minds and are worked out in laboratories.—Kettering

d. Most people think that when a discovery is made it comes all in a flash—that a new idea suddenly crops up—nothing is further from the truth.—Ramsay

e. Many a victory is won because one man keeps on a few minutes after his opponent has given up.—Garfield

2. Have you taken a new idea for your very own this week? Have you used it yet? Has it given you any newer ideas?

Science Words

This part of your book is a science dictionary. It will help you to find the meanings of words which are used in your book. The page number following each word shows you on what page the word is first found.

The following list of letter sounds will help you to use correctly the markings of your science words.

ă *as in* căt
ā *as in* māde
ȧ *as in* grȧss
â *as in* câre
ä *as in* bärn

ĕ *as in* nĕt
ē *as in* hē

ẽ *as in* hẽr
ē̇ *as in* bē̇gin

ĭ *as in* gĭft
ī *as in* rīde

ŏ *as in* tŏp
ō *as in* jōke

ô *as in* hôrse
ō̇ *as in* ō̇bey
ŏ *as in* sŏft

ŭ *as in* cŭp
ū *as in* mūsic
û *as in* bûrn
ū̇ *as in* ū̇nite

oi *as in* soil
o͝o *as in* to͝ok
o͞o *as in* mo͞on
ou *as in* loud
ng *as in* sing
th *as in* thin
~~th~~ *as in* ~~th~~at
t͜ū̇ *as in* pictū̇re

ad ap ta′tion (ăd ăp tā′shŭn). A method or means which helps an animal to overcome difficulties. A special structure which helps an animal to remain alive (p. 137)

am mo′ni a (ȧ mō′nĭ ȧ). A compound of nitrogen and hydrogen which is used in household cleaning. Ammonia is also used in purifying drinking water (p. 36)

as′ter oid (ăs′tẽr oid). A very small planet which travels around the sun between Mars and Jupiter (p. 72)

as tron′o mer (ăs trŏn′ō̇ mẽr). A scientist who studies heavenly bodies. Astronomers should not be confused with astrologers, who pretend to be able to tell the future by the position of the stars (p. 58)

at′mos phere (ăt′mŏs fēr). The layer of gases around a planet (p. 48)

ball bear′ings (bôl bâr′ĭngs). Small metal balls that roll between an axle and a wheel. Friction is reduced because the wheel rolls on the balls instead of on the axle (p. 159)

car′bon (kär′bŏn). An element which is present in compounds that are part of living or dead plants and animals. Coal is largely carbon. Diamonds are another form of carbon (p. 34)

car′bon di ox′ide (kär′bŏn dī ŏk′sīd). A colorless gas made of carbon and oxygen which animals exhale. Frozen carbon dioxide is called dry ice (p. 34)

chem′i cal (kĕm′ĭ kăl). All substances are composed of chemicals. Such things as air, food, and rocks are made of mixtures of chemicals (p. 36)

chlo′rine (klō′rĭn). A yellow-green gas which is used in small quantities to purify water. Chlorine combines with sodium to form table salt (p. 43)

cir′cuit (sûr′kĭt). A path for electricity (p. 183)

com′et (kŏm′ĕt). A body which comes from distant space, goes around our sun, and returns to distant space. The orbits of comets are not nearly so circular as those of the planets. Astronomers believe that comets are made of gases and small pieces of solid materials (p. 80)

com′pound (kŏm′pound). A substance composed of two or more elements in certain amounts. Water is a compound of hydrogen and oxygen. Every molecule of water contains the same amount of hydrogen and of oxygen as every other molecule. All compounds have a definite composition (p. 27)

con duc′tor (kŏn dŭk′tẽr). A material through which electricity passes easily (p. 179)

con ti nen′tal shelf (kŏn tĭ nĕn′tăl shĕlf). A sloping submarine plain at the edge of the ocean, which varies in width from 0 miles to 150 miles (p. 94)

con ti nen′tal slope (kŏn tĭ nĕn′tăl slōp). A steep drop in the ocean bed at the edge of the continental shelf (p. 95)

cor′al (kŏr′ăl). A small sea animal which builds a skeleton of limestone. Piles of coral skeletons may form unusual shapes (p. 107)

cor′al reef (kŏr′ăl rēf). A mountainous pile of coral skeletons of both living and dead animals. Coral reefs are found only in warm water (p. 108)

cra′ter (krā′tẽr). A circular ridge of high ground around a low, central portion of land (p. 63)

cyl′in der (sĭl′ĭn dẽr). A hollow metal tube. Engines have cylinders in which pistons are pushed back and forth (p. 146)

di am′e ter (dī ăm′ė tẽr). The distance straight through the center of a circle or planet (p. 51)

di′a toms (dī′ȧ tŏms). Small plants which build pillbox skeletons from chemicals in the ocean water. Diatoms cannot be seen without a microscope (p. 99)

elec tro mag′net (ė lĕk trō măg′nĕt). A magnet which is made by wrapping wire around a piece of soft iron and passing electricity through the wire. When electricity is turned off, the iron ceases to be a magnet (p. 184)

el′e ment (ĕl′ė mĕnt). A substance which consists of only one kind of matter. Elements combine to form compounds. Hydrogen, nitrogen, oxygen, iron, and silver are elements (p. 25)

ex per′i ment (ĕcks pĕr′ĭ mĕnt). A trial made to prove or disprove what one believes to be true (p. 6)

fric′tion (frĭk′shŭn). Resistance to motion. Friction causes heat and wear (p. 149)

gas (găs). The state of a substance in which it holds no definite shape or size of its own. The air is made of nitrogen, oxygen, carbon dioxide, and other gases (p. 7)

gram (grăm). A small weight used by scientists. A nickel weighs about five grams (p. 39)

grav i ta′tion al pull (grăv ĭ tā′shŭn ăl po͝ol). The pull of gravity on an object (p. 49)

grav′i ty (grăv′ĭ tĭ). A force which pulls objects toward the center of the earth. The pull between heavenly bodies is more often referred to as gravitation (p. 49)

gup′py (gŭp′ĭ). A small tropical aquarium fish which produces its young alive (p. 124)

he′li um (hē′lĭ ŭm). A light, colorless gas which is used to fill dirigibles. It does not burn (p. 33)

hook′worm (ho͝ok′wûrm). A parasitic worm which has hooks or spines around its mouth. Hookworms can burrow through a person's skin and cause hookworm disease (p. 331)

hy′dro gen (hī′drō̇ jĕn). A colorless gas which has no odor or taste. This element is the lightest substance known (p. 32)

il lu mi na′tion (ĭ lū mĭ nā′shŭn). Lighting (p. 255)

in′su la tor (ĭn′sū̇ lā tẽr). A material through which electricity will not pass easily. An insulator is a nonconductor (p. 179)

liq′uid (lĭk′wĭd). A form of matter which has size but no definite shape. A liquid will take the shape of the container into which it is poured (p. 6)

lu bri ca′tion (lū brĭ kā′shŭn). The oiling or greasing of surfaces to make them slippery. Lubrication reduces friction (p. 161)

mer′cu ry (mûr′kū̇ rĭ). A silvery liquid which is very heavy. An element (p. 34)

me′te or (mē′tē ẽr). A small body of mineral matter which moves about in the solar system. Meteors are frequently called shooting stars because they streak through the sky as they burn (p. 83)

me′te or ite (mē′tē̇ ẽr īt). A meteor which reaches the solid part of the earth (p. 84)

mol′e cule (mŏl′ē̇ kūl). The smallest particle, or bit, into which a substance can be divided and still remain the same substance. There are many thousands of molecules in a very small speck of dust (p. 12)

ni′chrome (nī′krōm). A combination of nickel and chromium which is used in the heating elements of toasters and electric heaters (p. 192)

ni′tro gen (nī′trȯ jĕn). A colorless gas which has no odor or taste. About 80 per cent of the air is composed of this element (p. 32)

ooze (o͞oz). The material which makes the floor of the deep ocean. Ooze is made from skeletons of plants and animals, pebbles, and volcanic ash (p. 97)

ox′y gen (ŏk′sĭ jĕn). A colorless gas which has no odor or taste. All living things need the element oxygen so that they can burn their food for energy (p. 26)

phas′es (fāz′ĕs). Regular monthly changes in the appearance of the moon (p. 63)

pis′ton (pĭs′tŭn). A piece of metal which fits tightly into a round tube and slides back and forth in the tube. The tube is called a cylinder (p. 146)

pis′ton rod (pĭs′tŭn rŏd). A long metal piece which is attached to a piston and moves back and forth with it (p. 146)

pitch′blende (pĭch′blĕnd). A brown or black mineral which shines like pitch. Pitchblende is a source of radium (p. 38)

plan′et (plăn′ĕt). A heavenly body which travels in a more or less circular path around the sun. The earth is a planet (p. 48)

poi′son su′mac (poi′z′n sū′măk). A smooth shrub with greenish-white berries that grows in swamps. Poison sumac contains an oil which causes skin poisoning (p. 340)

pouch (pouch). A pocket consisting of skin in which young animals may be carried. Kangaroos and sea horses are animals which have pouches (p. 127)

ra′di um (rā′dĭ ŭm). A rare element whose properties make it valuable in medicine. Radium and its compounds glow in the dark (p. 38)

reed (rēd). A thin elastic piece of material which is stretched across the air column of a musical instrument. When the reed vibrates, sound is produced (p. 261)

ring′worm (rĭng′wûrm). Any of several kinds of plants which are too small to be seen without a microscope but which cause skin disease (p. 333)

sar gas'sum weed (sär găs'ŭm wēd). A form of seaweed. Millions of tons of this weed form the Sargasso Sea in the Atlantic Ocean (p. 102)

so'lar sys'tem (sō'lẽr sĭs'tĕm). The sun and the heavenly bodies which travel around it. These bodies are planets and their moons, comets, asteroids, and meteors (p. 50)

sol'id (sŏl'ĭd). Any substance which has a definite shape and size. Wood, glass, and rocks are solids (p. 6)

stok'er (stōk'ẽr). A large screw that is used to carry coal into a furnace (p. 144)

su'mac. *See* poison sumac

sun spots (sŭn spŏts). Spots on the sun which are cooler and somewhat darker than the rest of the sun (p. 53)

su per sti'tion (sū pẽr stĭsh'ŭn). A false belief. Superstitions are not based on facts (p. 66)

sur vive' (sẽr vīv'). To remain alive (p. 121)

top'soil (tŏp'soil). The surface layer of soil which contains the materials which plants need for growing (p. 308)

tung'sten (tŭng'stĕn). A metal which is used in electric-light bulbs. Tungsten can be drawn into very fine wire (p. 194)

valve (vălv). A movable piece of metal which is connected to a piston rod in a steam engine (p. 147)

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